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Spontaneous Air Leak Syndromes in COVID-19: A Retrospective Analysis of 124 Patients

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ABSTRACT

Introduction: Air leak syndromes, including pneumothorax and pneumomediastinum, have emerged as important complications in patients with COVID-19, often occurring even in the absence of invasive respiratory support. This study aims to characterize the clinical features, severity, and outcomes of COVID-19 patients who developed spontaneous air leaks during their illness.

Methods: In this retrospective cohort study, 124 laboratory-confirmed COVID-19 patients who developed spontaneous pneumothorax and/or pneumomediastinum between March 20, 2020, and December 31, 2022, were evaluated. Demographics, comorbidities, smoking status, clinical severity, air leak characteristics, interventions, and outcomes were recorded and analyzed using descriptive and comparative statistics.

Results: The median age was 65.5 years, with 70.96% being male. Pneumothorax occurred in 87.10% of patients, pneumomediastinum in 16.12%, and 3.22% had both conditions. None of the patients were on ventilatory support when the air leak occurred. The median time from COVID-19 diagnosis to air leak development was seven days. High-grade (Grade 3–4) air leaks were identified in 70.2% of cases and were significantly more common in patients with severe or critical COVID-19 ($p = 0.002$). Active smokers had higher rates of severe air leakage compared to non-smokers (81.0% vs. 56.1%, $p = 0.011$). Mechanical ventilation was subsequently required in 95.16% of patients. Tube thoracostomy was performed in 82.25% of cases, and the in-hospital mortality was 8.06%.

Conclusions: Spontaneous air leak syndromes may occur early in the COVID-19 disease course and are associated with greater clinical severity and smoking status. These findings challenge the traditional view of barotrauma-related air leaks and suggest that underlying alveolar fragility plays a key role. Further prospective studies are needed to refine early recognition and management strategies in this high-risk population.

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Introduction

In December 2019, a novel coronavirus, later named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was identified as the causative agent of a respiratory illness that rapidly spread worldwide and led to the COVID-19 pandemic (1,2). While the primary manifestations of COVID-19 involve the respiratory system, a variety of pulmonary complications have been documented, especially in patients with

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severe disease (3,4).

Among these, air leak syndromes-including pneumothorax (PNX) and pneumomediastinum (PNM)-have gained increasing clinical attention. Traditionally considered complications of barotrauma induced by positive pressure ventilation (5,6), recent case reports and series have described spontaneous occurrences of these syndromes in COVID-19 patients without prior exposure to invasive or non-invasive ventilation (3,7-9). These observations suggest that the pathophysiology of SARS-CoV-2-related lung injury may predispose patients to alveolar rupture, even in the absence of external mechanical stress (10,11).

Spontaneous air leak syndromes in COVID-19 are hypothesized to result from diffuse alveolar damage, parenchymal fragility, and microvascular injury, which may be exacerbated by intense coughing or increased respiratory effort (6,11). In some cases, the Macklin effect- a process involving alveolar rupture and air dissection along bronchovascular sheaths- has been implicated as the underlying mechanism (3). Additionally, underlying lung pathologies and comorbidities such as chronic obstructive pulmonary disease (COPD) or fibrosis may increase the risk of spontaneous air leak development (12).

Despite accumulating case-based evidence, data on the incidence, timing, clinical characteristics, and outcomes of these complications in larger cohorts remain limited. In this study, we retrospectively analyzed the clinical profiles, management, and outcomes of 124 COVID-19 patients who developed spontaneous pneumothorax and/or pneumomediastinum during the course of their illness, prior to the initiation of any respiratory support. This work aims to provide a more comprehensive understanding of the natural course and implications of spontaneous air leak syndromes in the setting of COVID-19.

Materials and Methods

Study Design and Patient Selection

This single-center retrospective study included 124 patients with confirmed COVID-19 infection who developed spontaneous air leak syndromes—either pneumothorax, pneumomediastinum, or both—during their hospitalization between March 20, 2020, and December 31, 2022. All cases were identified through hospital database screening using ICD codes and confirmed by radiological evidence.

Inclusion criteria were:

- Laboratory-confirmed SARS-CoV-2 infection via RT-PCR
- Radiologically or clinically confirmed diagnosis of pneumothorax and/or pneumomediastinum
- Onset of air leak syndrome prior to the initiation of any form of respiratory support (oxygen mask, non-invasive ventilation [NIV], or invasive mechanical ventilation [IMV])

Exclusion criteria were:

- History of trauma
- Prior thoracic surgery
- Pre-existing bullous lung diseases

The study was approved by the institutional ethics committee (Date: June 23, 2023; Protocol No: 2023.130.06.16). Due to the retrospective nature of the study, the requirement for informed consent was waived.

Data Collection

Demographic and clinical data were collected from electronic health records, including the following parameters :

- Age and sex
- Smoking status
- Comorbidities (e.g., hypertension, diabetes, cardiovascular disease, malignancy)
- Type and timing of air leak (PNX, PNM, or both)
- Severity of pneumothorax
- Localization and size of pneumothorax
- Respiratory support initiated after air leak development
- Treatment modalities for air leak (tube thoracostomy, conservative, or surgical)
- Duration of hospitalization and ICU stay
- COVID-19 severity

- Time from COVID-19 diagnosis to air leak onset
- In-hospital mortality

To assess the severity of spontaneous air leak syndromes, each case was graded according to a four-level scale based on the extent and continuity of air leakage observed on digital drainage systems and clinical course. The grading system consisted of four levels, with Grade 1 defined as minimal air leakage detectable only during coughing, Grade 2 as intermittent leakage during respiration, Grade 3 as continuous leakage during the expiratory phase, and Grade 4 as persistent leakage throughout both inspiration and expiration phases. For further statistical analysis, cases were categorized as Grade 3–4 air leaks if they exhibited continuous bubbling during both inspiration and expiration or required prolonged chest drainage exceeding 5 days.

Additionally, patients were stratified by COVID-19 severity (mild, moderate, severe, critical) based on World Health Organization (WHO) clinical progression criteria. The frequency of high-grade air leaks (Grade 3–4) was then compared across these severity groups.

Smoking history was also evaluated. Patients were divided into active smokers and non-smokers based on electronic health records and admission interviews. The associations between smoking status and clinical outcomes—including high-grade air leakage, ICU admission, and in-hospital mortality— were analyzed.

Radiologic confirmation was obtained through chest X-ray or thoracic computed tomography (CT). In patients too unstable for imaging, the diagnosis was made based on clinical findings (sudden oxygen desaturation, subcutaneous emphysema, or absent breath sounds) as assessed by expert clinical examination. Treatment decisions were made by the attending thoracic surgeon and intensive care team.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA). The normality of data distribution was assessed using the Shapiro-Wilk test. Continuous variables were reported as mean ± standard deviation or median (range) depending on the distribution. Categorical variables were summarized as frequencies and percentages. A significance threshold of $p < 0.05$ was utilized.

Result

The study involved 124 patients, 88 males, and 36 females, with a median age of 65.5 years (range: 19–88 years). Comorbidities were present in 67.74% of cases, with hypertension, cardiovascular disease, diabetes mellitus, and malignancies being the most common (Table 1).

Air leak syndromes developed spontaneously in all patients, without prior use of mechanical or non-invasive ventilation. Pneumothorax was observed in 108 patients (87.10%), while pneumomediastinum occurred in 20 patients (16.12%). Four patients presented with both complications simultaneously. Among the pneumothorax cases, the right lung was affected in 59.67% of patients, the left in 19.35%, and bilateral involvement was seen in 8.06%.

Among the 114 patients with confirmed spontaneous air leaks, 80 (70.2%) were classified as having Grade 3–4 air leakage. The frequency of high-grade leakage increased significantly with disease severity, being lowest in mild cases (28.6%) and highest in the severe and critical groups (84.2% and 75.0%, respectively) ($p = 0.002$) (Table 2).

When stratified by smoking status, active smokers demonstrated a significantly higher rate of Grade 3–4 air leakage compared to non-smokers (81.0% vs. 56.1%, $p = 0.011$). However, ICU admission rates and in-hospital mortality were comparable between the two groups ($p = 1.00$ for both comparisons), suggesting that while smoking may be associated with more severe air leak presentations, it does not significantly impact short-term survival in this cohort (Table 3).

The median time from COVID-19 diagnosis to air leak onset was seven days (range: 1–51 days). At the time of air leak detection, none of the patients were under any form of assisted ventilation; however, respiratory deterioration following the air leak necessitated subsequent support. Invasive

mechanical ventilation was eventually required in 118 patients (95.16%), while 4 patients (3.22%) received non-invasive ventilation and 2 (1.61%) received high-flow oxygen therapy.

Tube thoracostomy was performed in 102 patients (82.25%). Surgical intervention was needed in 2 cases (1.61%) due to persistent air leak, while 20 patients (16.12%) were managed conservatively. A total of 120 patients (96.77%) were admitted to the intensive care unit. The median length of hospital stay was 16 days (range: 1–73), with a median ICU stay of 13 days (range: 0–42).

Despite comprehensive management, 10 patients (8.06%) died during hospitalization. Most deaths occurred in elderly patients with multiple comorbidities and severe bilateral lung involvement.

These findings suggest that in COVID-19, spontaneous air leak syndromes can emerge early, even before respiratory support initiation, and are associated with a severe clinical trajectory requiring ICU-level care in most cases.

Table 1. The clinical characteristics of patients.

Characteristics	N
Age, years (range)	65.5 (19- 88)
Gender, n (%)	
Male	88 (70.96%)
Female	36 (30.04%)
Length of hospital stay, days (range)	16 (1-73)
Length of ICU stay, days (range)	13 (0-42)
The side of air leakage, n (%)	
Left	74 (59.67%)
Right	24 (19.35%)
Bilateral	10 (8.06%)
The size of pneumothorax, n (%)	
Minimal (<%5)	112 (90.3)
Moderate (%5-10)	12 (9.7)
History of pneumothorax	0 (0%)
Pneumomediastinum, n (%)	20 (16.12)
Comorbidities, n (%)	84 (67.74)
Treatment, n (%)	
Tube thoracostomy	102 (82.3)
Operated	2 (1.6)
Conservative	20 (16.1)
Respiratory support, n (%)	
IMV	118 (95.7),
NIMV	4 (3.2)
Mask	2 (1.7)
Need for ICU, n (%)	118 (95.2)
Mortality, n (%)	10 (8.1)

ICU: Intensive Care Unit; **IMV:** Invasive Mechanical Ventilation; **NIMV:** Non-Invasive Mechanical Ventilation.

Table 2. Distribution of COVID-19 severity and air leak types.

COVID-19 severity*	No. of patients (n)	Grade 3–4 air leakage (n, %)	p-value
Mild	14	4 (28.6%)	0.002
Moderate	22	14 (63.6%)	-
Severe	38	32 (84.2%)	-
Critical	40	30 (75.0%)	-

* Based on World Health Organization clinical progression criteria.

Table 3. Outcomes by smoking status.

Smoking status	Grade 3–4 air leakage (n, %)	ICU admission (n, %)	Mortality (n, %)
Active smokers (n=42)	34 (81.0%)	40 (95.2%)	3 (7.1%)
Non-smokers (n=82)	46 (56.1%)	78 (95.1%)	7 (8.5%)
p-value	0.011	1.00	1.00

ICU: Intensive Care Unit

Discussion

Air leak syndromes, including pneumothorax (PNX) and pneumomediastinum (PNM), have traditionally been regarded as complications primarily associated with barotrauma during invasive mechanical ventilation (IMV) (5-7). However, the emergence of COVID-19 has challenged this understanding, as multiple reports have documented spontaneous occurrences of these complications even in the absence of positive pressure ventilation (3,9,10). The pathophysiological mechanisms likely involve diffuse alveolar damage, disruption of the alveolar-capillary membrane, and increased intrathoracic pressures secondary to severe coughing or respiratory effort (1,6).

In our study, all patients developed PNX and/or PNM spontaneously, without prior exposure to non-invasive or invasive respiratory support. Notably, respiratory support was initiated only after the onset of the air leak, as a response to progressive respiratory deterioration. This sequence strongly supports the hypothesis that alveolar rupture in COVID-19 can occur independently of mechanical ventilation, driven instead by intrinsic pulmonary pathology and fragile lung parenchyma (10,11).

The patient population was predominantly male, with a median age of 65.5 years. A substantial proportion had comorbidities such as cardiovascular disease, diabetes mellitus, and malignancy — all known to be associated with severe COVID-19 progression and poorer outcomes (13-16). Although previous studies have reported mixed findings regarding the association between comorbidities and the risk of air leak syndromes (13), our results suggest that older age and comorbid status may be contributing factors to the development of spontaneous PNX/PNM. Importantly, none of our patients had a prior history of pneumothorax or pneumomediastinum.

Our findings suggest a potential association between both COVID-19 severity and active smoking with the development of high-grade spontaneous air leak syndromes. The significantly higher rate of Grade 3–4 air leakage observed in patients with more severe forms of COVID-19 may reflect the extent of diffuse alveolar damage and increased intrathoracic pressure resulting from vigorous coughing or respiratory distress. Additionally, active smokers demonstrated a higher incidence of severe air leak, which is consistent with the hypothesis that chronic smoke exposure leads to increased alveolar fragility and impaired tissue repair mechanisms. While smoking status did not appear to influence ICU admission or mortality in our cohort, the disproportionate frequency of severe air leakage in smokers highlights the need for early radiologic assessment and vigilant monitoring in this subgroup.

Previous literature has described PNX and PNM as late complications, often developing after two to three weeks of illness or prolonged ventilation (12,17-19). However, in our cohort, the median time to air leak onset was seven days from COVID-19 diagnosis, indicating that these events may occur early in the disease course, possibly even during the initial inflammatory or proliferative phase of diffuse alveolar injury (8).

Following the onset of PNX/PNM, most patients in our study required intensive care and invasive mechanical ventilation. Despite this, the mortality rate was relatively low (8.06%), which is noteworthy given the severity of the cases and the extensive resource utilization. This suggests that timely and appropriate respiratory support — even after the onset of spontaneous air leak — can

be safe and potentially lifesaving when applied under careful monitoring (17,20,21). Furthermore, chest tube insertion remains a crucial component of PNX management (4,5). During the COVID-19 pandemic, concerns were raised regarding infection risk during tube thoracostomy procedures. In this context, practical strategies and protective protocols for safe chest tube application and follow-up were described by Ceylan et al., offering a valuable framework for thoracic surgeons and ICU teams (21).

These findings reinforce the importance of early recognition of air leak syndromes in COVID-19 patients, even in those not receiving ventilatory support. Clinicians should maintain a high index of suspicion, particularly in older, comorbid patients with sudden clinical deterioration, and consider prompt imaging to detect these complications.

Conclusion

This study highlights that spontaneous pneumothorax and/or pneumomediastinum in COVID-19 can occur early and without prior ventilatory support, challenging the traditional view of air leak syndromes as ventilation-related complications (3-10).

High-grade (Grade 3–4) air leaks were common (70.2%) and correlated with disease severity ($p = 0.002$). Active smokers had significantly higher rates of severe air leaks compared to non-smokers (81.0% vs. 56.1%, $p = 0.011$), suggesting increased alveolar fragility. Despite high ICU admission rates, overall mortality remained low and comparable between groups ($p = 1.00$).

These findings emphasize the need for vigilance in high-risk patients and support early respiratory intervention when air leak syndromes occur (21).

Conflicts of interest

The authors certify that there are no conflicts of interest with any financial organization regarding the material discussed in the manuscript.

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References

1. Li H, Liu Z, Ge J. Scientific research progress of COVID-19/SARS-CoV-2 in the first five months. Journal of cellular and molecular medicine. 2020 Jun;24(12):6558-70.
2. Sohrabi C, Alsafi Z, O'neill N, Khan M, Kerwan A, Al-Jabir A, et al. World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19). International journal of surgery. 2020 Apr 1;76:71-6.
3. Brito J, Gregório P, Mariani A, D'ambrosio P, Filho M, Ferreira L, et al. Pneumomediastinum in COVID-19 disease: outcomes and relation to the Macklin effect. Asian Cardiovascular and Thoracic Annals. 2021 Jul;29(6):541-8.
4. Papagiannis A, Lazaridis G, Zarogoulidis K, Papaiwannou A, Karavergou A, Lampaki S, et al. Pneumothorax: an up to date "introduction". Annals of translational medicine. 2015 Mar;3(4):53.
5. Noppen M, De Keukeleire T. Pneumothorax. Respiration. 2008 Feb 1;76(2):121-7.
6. Kouritas VK, Papagiannopoulos K, Lazaridis G, Baka S, Mpoukovinas I, Karavasilis V, et al. Pneumomediastinum. J Thorac Dis. 2015; 7 (Suppl 1): S44-S49 [Internet].
7. Ferguson ND, Frutos-Vivar F, Esteban A, Anzueto A, Alía I, Brower RG, et al. Airway pressures, tidal volumes, and mortality in patients with acute respiratory distress syndrome. Critical care medicine. 2005 Jan 1;33(1):21-30.
8. De Latorre FJ, Klamburg J, Leon C, Soler M, Rius J. Incidence of pneumothorax and pneumomediastinum in patients with aspiration pneumonia requiring ventilatory support. Chest. 1977 Aug 1;72(2):141-4.
9. Chong WH, Saha BK, Hu K, Chopra A. The incidence, clinical characteristics, and outcomes of pneumothorax in hospitalized COVID-19 patients: a systematic review. Heart & Lung. 2021 Sep 1;50(5):599-608.
10. Chopra A, Al-Tarbsheh AH, Shah NJ, Yaqoob H, Hu K, Feustel PJ, et al. Pneumothorax in critically ill patients with COVID-19 infection: incidence, clinical characteristics and outcomes in a case control multicenter study. Respiratory medicine. 2021 Aug 1;184:106464.
11. Noppen M. Spontaneous pneumothorax: epidemiology, pathophysiology and cause. European Respiratory Review. 2010 Sep;19(117):217.

12. Kecskes G, Szabo A, Sutori D, Maroti P, Marovics G, Molnar TF. Pneumothorax/pneumomediastinum and pre-existing lung pathology in ventilated COVID-19 patients: a cohort study. Journal of Thoracic Disease. 2022 Dec;14(12):4733.
13. Lee SJ, Kim J, Lee KH, Lee JA, Kim CH, Lee SH, et al. Risk factors of pneumothorax and pneumomediastinum in COVID-19: a matched case–control study. BMC Infectious Diseases. 2023 Mar 7;23(1):137.
14. Büyükkarabacak Y, Pirzirenli MG, Gurz S, Abacı H, Şengül AT, Çelik B, et al. COVID-19 and pneumothorax, pneumomediastinum, subcutaneous emphysema: Analysis of risk factors. Turkish Journal of Thoracic and Cardiovascular Surgery. 2023 Jan 30;31(1):69.
15. Polatoğlu I, Oncu-Oner T, Dalman I, Ozdogan S. COVID-19 in early 2023: Structure, replication mechanism, variants of SARS-CoV-2, diagnostic tests, and vaccine & drug development studies. MedComm. 2023 Apr;4(2):e228.
16. Yang F, Shi S, Zhu J, Shi J, Dai K, Chen X. Analysis of 92 deceased patients with COVID-19. Journal of medical virology. 2020 Nov;92(11):2511-5.
17. Nistor CE, Gavan CS, Pantile D, Tănase NV, Ciuche A. Cervico-Thoracic Air Collections in COVID-19 Pneumonia Patients—Our Experience and Brief Review. Chirurgia. 2022 Jun;117:317-27.
18. Belletti A, Palumbo D, Zangrillo A, Fominskiy EV, Franchini S, Dell'Acqua A, et al. Predictors of pneumothorax/pneumomediastinum in mechanically ventilated COVID-19 patients. Journal of cardiothoracic and vascular anesthesia. 2021 Dec 1;35(12):3642-51.
19. Martinelli AW, Ingle T, Newman J, Nadeem I, Jackson K, Lane ND, et al. COVID-19 and pneumothorax: a multicentre retrospective case series. European Respiratory Journal. 2020 Nov 19;56(5).
20. Elhakim TS, Abdul HS, Romero CP, Rodriguez-Fuentes Y. Spontaneous pneumomediastinum, pneumothorax and subcutaneous emphysema in COVID-19 pneumonia: a rare case and literature review. BMJ Case Reports CP. 2020 Dec 1;13(12):e239489.
21. Ceylan KC, Batihan G, Yazgan S, Gürsoy S, Kıraklı SC, Ataman S. Pleural complications in patients with coronavirus disease 2019 (COVID-19): how to safely apply and follow-up with a chest tube during the pandemic?. European Journal of Cardio-Thoracic Surgery. 2020 Dec;58(6):1216-21.