

ORIGINAL RESEARCH

INTENSIVE CARE

Spontaneous pneumothorax in critically ill patients with COVID-19

Deniz Heppekan ¹, Egemen Ümit Hazar ²

Author affiliations:

1. Deniz Heppekan, Cevizli Mah. 30 Ağustos Cad. No 9-11 Başyapıt Dragos Daire:83 Maltepe-İstanbul-Turkey; {ORCID: [0000-0002-3217-1387](https://orcid.org/0000-0002-3217-1387)}
2. Egemen Ümit Hazar, Zonguldak Atatürk Devlet Hastanesi, Meşrutiyet, Uzun Mehmet Cd. No:5, 67030 Zonguldak -Turkey; E-mail: egemenumithazar@gmail.com; {ORCID: [0009-0009-8133-1525](https://orcid.org/0009-0009-8133-1525)}

Correspondence: Egemen Ümit Hazar; **E-mail:** egemenumithazar@gmail.com; **Phone:**90 5444902222; **Mobile:** 90 5444902222

ABSTRACT

Background & Objective: Coronavirus disease 2019 (COVID-19) claimed thousands of the lives during a limited period of time, but also enriched our scientific knowledge, especially regarding the respiratory pathogenesis and intensive care dynamics. This study was carried out to bridge the gap in the literature regarding the incidence, clinical features, and outcomes of spontaneous pneumothorax (SP) that develops during the course of COVID-19.

Methodology: The population of this single-center retrospective study consisted of all critically ill adult patients who tested positive for COVID-19, developed SP, and were admitted to the intensive care units (ICUs) of Acibadem University School of Medicine, Training and Research Hospital, between March 21, 2020 and May 31, 2021. Detailed medical records, clinical findings, chest computed tomography (CT) scans, and X-ray images of critically ill COVID-19 patients complicated by SP were obtained and analyzed.

Results: Of the 753 patients admitted to the ICUs during the study period, 600 tested positive for COVID-19 viral pneumonia. Of these patients, 549 met the diagnostic criteria for acute respiratory distress syndrome (ARDS), of whom 472 were treated with invasive mechanical ventilation (IMV) and 77 were treated without IMV. SP developed in a total of five (0.8%) patients, 4 (0.9%) of whom were on IMV support and 1 (1.2%) of whom was breathing spontaneously. Of these patients who developed SP, one patient on IMV support was female, and the remaining four were male. The median age of these five patients was 42 (33-64) years. Two (40%) of the five patients died in ICU.

Conclusion: The actual incidence of COVID-19-related spontaneous pneumothorax is yet to be elucidated and may require a large scale, multi-center study. COVID-19-related spontaneous pneumothorax is similar to ARDS-related spontaneous pneumothorax without COVID-19 in terms of clinical features and outcomes, its risk of occurrence is higher.

Abbreviations: COVID-19 - Coronavirus disease 2019; CT - computed tomography; IMV - invasive mechanical ventilation; SP - spontaneous pneumothorax

Keywords: SARS-Cov-2; COVID-19; Spontaneous Pneumothorax

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1. INTRODUCTION

Several studies addressing the clinical course of coronavirus disease-2019 (COVID-19) have identified possible risk factors for the transmission and severity of COVID-19.¹⁻⁴ The severe acute respiratory syndrome

coronavirus 2 (SARS-CoV-2), which causes COVID-19, can target many organs in the human body, although the most affected organ in critically ill patients is the lung. Patients experiencing progressive respiratory distress due to COVID-19 are potential intensive-care patients.

Acute respiratory distress syndrome (ARDS), which develops secondary to SARS-CoV-2 pneumonia, is the most common diagnosis, with a rate of 85-90% in COVID-19 patients treated in intensive care units (ICUs).^{5,6} Severe viral pneumonias causes severe ARDS that require invasive mechanical ventilation (IMV). According to the results of the 2016 large observational study to understand the global impact of severe acute respiratory failure (LUNG SAFE) study, non-COVID ARDS accounts for 10.4% of ICU admissions, with a very high mortality rate of approximately 40%.⁷ Although different mortality rates have been reported in studies conducted in various countries, the estimated overall pooled mortality rate of COVID-19-related ARDS is 39%, similar to that of non-COVID-19 ARDS.⁸

Pathophysiological changes that occur in the background of ARDS due to severe damage to the lung caused by the SARS-CoV-2 cause air leaks in some patients. Air leaks outside the tracheobronchial tree, such as pneumothorax, pneumomediastinum, and subcutaneous emphysema, are complications seen in patients with ARDS, breathing spontaneously or requiring mechanical ventilation. Spontaneous pneumothorax (SP) refers to the abnormal collection of air in the pleural space between the lung and the chest wall without any trauma. Although a few case series/reports regarding COVID-19-related SP and other air leak pathologies were published in the early periods of the pandemic, the number of observational studies on this subject has increased recently.⁹⁻¹² The development of pneumothorax in patients has been attributed to the pathophysiology of ARDS in some studies and to barotrauma caused by mechanical ventilation in others. However, the effects of both ARDS pathogenesis and MV-induced barotrauma are intertwined in tracheobronchial air leaks in COVID-19 patients.

We carried out this study to investigate the clinical course and outcomes of patients with SP and accompanying pneumomediastinum, subcutaneous emphysema in patients admitted to the ICUs of our hospital due to ARDS secondary to COVID-19 viral pneumonia.

2. METHODOLOGY

This study was designed as a single-center retrospective study. The study protocol was approved by the Medical Ethical Committee of Acibadem University (Approval number 2021-10/28).

The study population consisted of all critically ill adult patients, tested positive for COVID-19, developed SP,

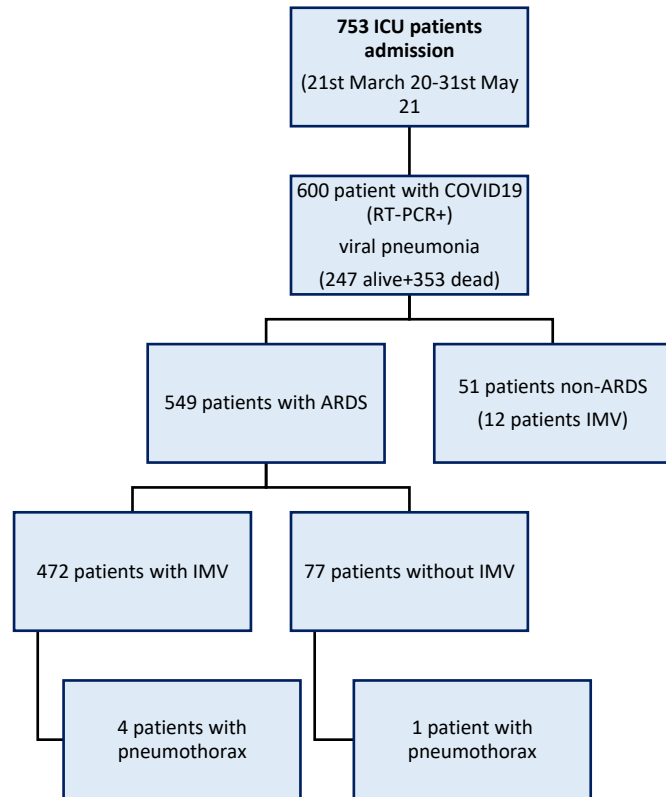


Figure 1: Study Flowchart

and were admitted to the intensive care units (ICUs) of Acibadem University School of Medicine Training and Research Hospital in March 21, 2020 to May 31, 2021. COVID-19 diagnosis was based on the real-time reverse transcription polymerase chain reaction (RT-PCR) testing of nasopharyngeal swabs or endotracheal aspirate specimens.

Of the 753 patients admitted to the ICUs during the study period, 600 tested positive for COVID-19 viral pneumonia. All patients underwent a chest computed tomography (CT) scan upon admission to the hospital. ARDS diagnosis was based on 2012 Berlin definitions.¹³ Of the 600 patients with COVID-19, 549 met the diagnostic criteria for ARDS. SP diagnosis was based on clinical documentation and chest X-ray imaging. Patients who developed SP at any time during the clinical course of COVID-19 were reviewed. Patients under 18 y, patients who were pregnant, followed up outside our ICU, and whose hospital data were missing or insufficient were excluded from the study. In the end, the study sample consisted of five patients who developed SP. The study’s flowchart is shown in Figure 1.

Table 1: Demographic and clinical details of all SP cases

Parameter	Case 1 (SB)	Case 2 (ME)	Case 3 (GC)	Case 4 (RC)	Case 5 (MA)
Sex	Male	Male	Female	Male	Male
Age (Y)	33	38	40	64	38
Smoking history	N.S	N.S	N.S	Ex-S	N.S
Ch. lung disease	No	No	No	Yes	No
Rt-PCR	+	+	+	+	+
Other comorbidities	No	No	No	Yes	Yes
Side of SP	Left	Left	Right	Bilateral	Right
Day of SP	15	26	22	3	31
Subcutaneous emphysema	No	No	No	Yes	Yes
Pneumomediastinum	No	No	No	No	Yes
Severity of ARDS	Mild	Severe	Severe	Severe	Severe
Mode of Breathing	Spontaneous Breathing	IMV	IMV	IMV	IMV
Mode of Diagnosis	Clinical Change	Clinical Change	Clinical Change	Clinical Change	Clinical Change
IMV duration before SP (day)	N/A	25	7	1	12
Management of PT	Chest Drain	Chest Drain	Chest Drain	Chest Drain	Chest Drain
Neuromuscular blockers	N/A	Yes	Yes	Yes	Yes
Recruitment maneuver	N/A	Yes	Yes	Yes	No
Lung-protective ventilation	N/A	Yes	Yes	Yes	Yes
Prone position	No	No	No	No	No
ECMO	N/A	No	No	No	No
CT features: (on admission)					
Ground- glass opacity	Yes	Yes	Yes	No	Yes
Consolidation	Yes	No	No	Yes	Yes
Fibrosis	No	No	No	No	No
Pulmonary cysts	No	No	No	No	No
Emphysema	No	No	No	No	No
Pleural Effusion	No	No	No	Yes	Yes
Outcome	Alive	Alive	Alive	Died	Died
From occurrence of SP to death (days)	N/A	N/A	N/A	7	1
Length of hospital stay (days)	28	114	40	11	32

3. RESULTS

Of the 753 patients admitted to the ICUs during the study period, 600 tested positive for COVID-19 viral pneumonia. The overall mortality rate was 58.8% (n = 353). Of the 600 patients with COVID-19, 549 met the diagnostic criteria for ARDS, of whom 472 were treated with IMV and 77 were treated without IMV. Of the 549 patients with ARDS, 51 had COVID-19 viral pneumonia without ARDS. SP developed in a total of 5 (0.8%) patients, 4 (0.9%) of whom were on IMV support and 1 (1.2%) of whom was breathing spontaneously. The characteristics of patients with SP are summarized in Table 1.

Of the five patients who developed SP, one patient on IMV support was female, and the remaining four were male. The median age of these five patients was 42 (min. 33, max. 64) y. Two (40%) of the five patients died in ICU. None of the three surviving patients had chronic lung disease or any other comorbidities and had never smoked. Both patients who died had comorbidities. One had chronic obstructive pulmonary disease (COPD), and the other had chronic renal failure. Both were ex-smokers. Of the five patients with CP, the spontaneously breathing patient had mild ARDS, while the others who were on IMV support had severe ARDS. Chest CT scans

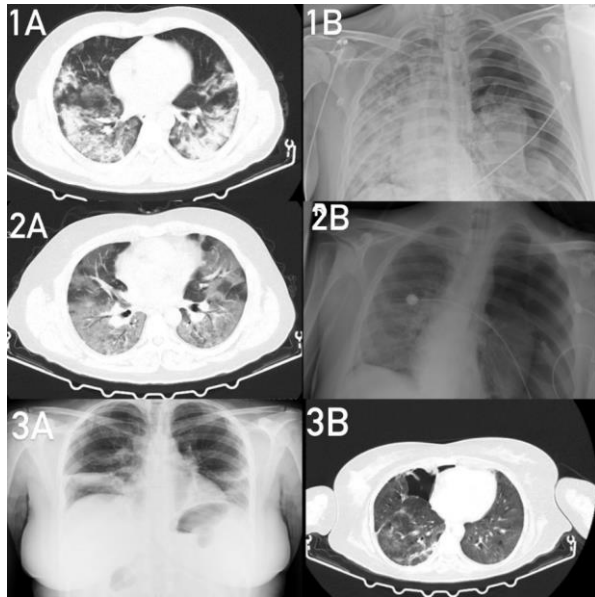


Figure 2: Chest X-ray and CT scan of surviving cases; 1A, 2A, and 3A imaging at admission. 1B, 2B, and 3B imaging on occurrence of SP.

revealed diffuse bilateral patchy ground glass opacities in surviving patients and consolidation and pleural effusion in deceased patients. Chest X-ray and CT scans of surviving and deceased cases are shown in Figures 2 and 3, respectively. Pneumothorax management was performed with chest drainage in all five patients. No significant difference was observed between these patients in terms of the side of the pneumothorax. Two had left-sided, two had right-sided, and one had bilateral SP. The characteristics of patients with SP are summarized in Table 1.

4. DISCUSSION

In this study, we investigated the incidence of SP in patients treated with or without IMV for COVID-19-related ARDS in our ICUs and the relevant clinical findings, course, and outcomes of these patients.

4.1. Incidence

A systematic review including nine observational studies reported the overall incidence of SP in hospitalized COVID-19 patients as 0.3% and between 12.8% and 23.8% in critically ill COVID-19 patients who required IMV.¹⁴ Zantah et al. reported the incidence of SP in hospitalized COVID-19 patients as 0.66%.¹⁰ Wang et al. found the incidence of SP as high as 56% in patients requiring IMV.¹⁴ In comparison, we found the overall incidence of SP in critically ill patients with COVID-19 and ARDS to be 0.83%. The incidence of SP was 0.9%

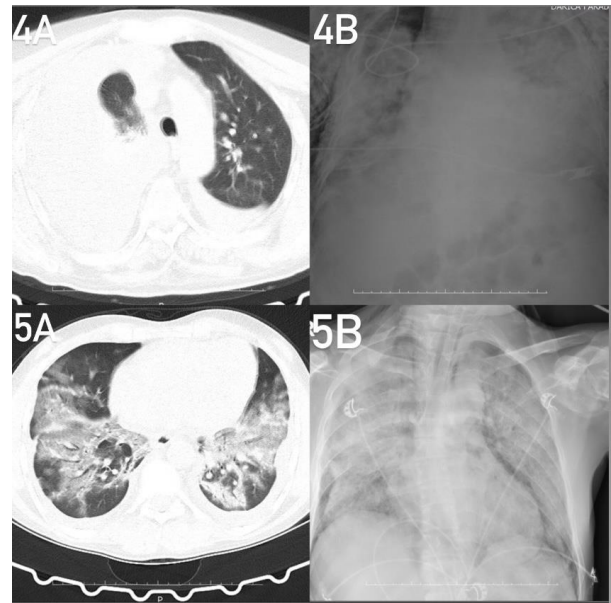


Figure 3: Chest X-ray and CT scan of dead cases. 4A, and 5A imaging at admission.

in patients who required IMV and 1.2% in patients who did not require IMV.

4.2. Patients' characteristics

In a retrospective multicenter study conducted by Ekanem et al., the median age of the COVID-19 patients with SP, 82% of whom were male, was 60 y.¹⁵ In comparison, in our study, the median age of five COVID-19 patients with SP, of whom 80% were male, was 42 years.

Another study reported that most SP cases had unilateral, right-sided SP.¹⁶ In comparison, most (80%) of our SP cases also had unilateral SP, but there was no significant difference between these patients in terms of the side of the pneumothorax.

Lastly, several studies reported that most SP cases required chest tube drainage within the scope of SP management in COVID-19 ARDS.^{10,14,15} In comparison, *all* of our cases required chest tube drainage.

4.3. Risk factors

ARDS is an independent risk factor for SP in patients receiving IMV support.¹⁷ In other words, pathophysiological changes in the lungs in ARDS cause high airway pressure rather than mechanical ventilation, causing barotrauma.^{17,18} It is the barotrauma caused by mechanical ventilation added to the inflammatory process in the lung parenchyma that affects oxygenation, weaning, and survival in COVID-19 ARDS patients, rather than the lung diseases already present in most patients. As a matter of fact, four of our SP cases did not

have any chronic pulmonary disease and did not smoke. Some studies have shown that smoking does not increase the risk of hospitalization or the development of critical illness in COVID-19 patients.¹⁹ The lung-protective ventilation strategy has been correlated with a higher rate of weaning from mechanical ventilation and a lower rate of barotrauma in patients with ARDS.²⁰ In addition, prone positioning during mechanical ventilation has been reported to improve survival in ARDS patients receiving protective lung ventilation.^{21–23} None of our SP cases were placed in the prone position. However, the lung-protective ventilation strategy was applied in 4 cases requiring IMV. Two (50%) of these 4 cases were lost. Four of the SP cases included in our sample were 40 years of age or younger.

4.4. Outcomes

SP-related mortality rates in COVID-19 patients reported in the literature vary between 2.9% and 88%.^{10,14,15,24,25} In comparison, SP-related mortality of the critically ill COVID-19 patients included in our sample was 40%. Chest CT scans of our deceased patients taken at the time of their admission to ICU revealed consolidation and pleural effusion, unlike our surviving patients. Additionally, both of our deceased patients had comorbidities. While the one over the age of 65 had a chronic lung disease, the one under the age of 40 was on a routine hemodialysis program due to chronic renal failure.

5. LIMITATIONS

The study's primary limitation was its retrospective design; that is, patient data were accessed from hospital records, and therefore, detailed medical records were not available.

The study's secondary limitation was its single-center design; only patients in the ICU of a city hospital were included in the study population.

6. CONCLUSION

Spontaneous pneumothorax is a life-threatening complication that requires rapid diagnosis and urgent treatment in COVID-19 patients with severe respiratory failure, with or without IMV support. Our study's findings indicate that COVID-19-related spontaneous pneumothorax may prolong the stay of patients in the ICU and hospital, and may cause an increase in mortality rates, especially in those over 65 years of age and with comorbidities. It may not be possible to precisely determine the incidence and mortality rate of spontaneous pneumothorax with retrospective studies conducted under pandemic conditions. Therefore, future

prospective observational studies are needed to reach more definitive conclusions.

7. Data availability

The numerical data generated during this research is available with the authors.

8. Acknowledgement

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9. Conflict of interest

The study utilized the hospital resources only, and no external or industry funding was involved.

10. Authors' contribution

DH: Concept, conduct of the study, translation

EUH: Statistical analysis, collection of the patient data, editing the draft manuscript

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