

Pulmonary interstitial emphysema and complications: Incidence and CT findings in COVID-19

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ABSTRACT

Background and Objectives: There are scant data available in the published literature providing chest computed tomography (CT) findings on pulmonary interstitial emphysema (PIE), complications and associated parenchymal abnormalities. We report the incidence of PIE and complications by chest CT in patients with COVID-19. **Methods:** We retrospectively analyzed 897 chest CT scans performed with 64-slice CT scanners during the COVID-19 pandemic period from March 2020 to September 2021. Two radiologists and two physicians in training in diagnostic radiology, independently and in consensus, assessed PIE as air within the perilobular (low-attenuation area) and perivascular interstitium such as its complications, parenchymal anomalies and pleural effusion; in addition, the complications of PIE, parenchymal anomalies and pleural effusion were evaluated. Descriptive statistics were used to summarize the data, and the results were expressed as counts and percentages. **Results:** PIE was revealed in 25 out of 897 patients (2.8%) and associated with pneumomediastinum, subcutaneous emphysema, and pneumothorax in 25 (100%), 16 (64%), and 7 (28%), patients, respectively. Out of 25 patients, 24 patients had ground-glass opacity (GGO), 23 patients had crazy paving, 22 patients had consolidation and 2 patients had pleural effusion. Eighteen out of 25 patients had noninvasive ventilation before CT scan, initially treated with continuous positive airway pressure (positive end expiratory pressure [PEEP] of 10 cmH₂O) and subsequently with bilevel positive airway pressure (range PEEP of 8–12 cmH₂O). The remaining seven patients had invasive mechanical ventilation via orotracheal intubation (pressure plateau at approximately 25 cmH₂O). Six out of 25 (24%) patients died. **Conclusion:** Chest CT allows the detection of complications associated with PIE and parenchyma abnormalities. The timely detection of PIE and minimal pneumomediastinum could aid the optimization of ventilation modalities and parameters based on patients clinical status therefore potentially reducing complications.

KEY WORDS: Chest computed tomography (CT), coronavirus disease (COVID-19), pulmonary interstitial emphysema (PIE), complications, pneumomediastinum

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INTRODUCTION

Coronavirus disease (COVID-19), histologically associated with diffuse alveolar damage (DAD),^{1,2} may cause acute

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respiratory distress syndrome. DAD is correlated to pulmonary and vascular abnormalities well recognizable on chest computed tomography (CT) examination;^[3,4] in addition, rupture of the alveolar walls can occur causing pulmonary interstitial emphysema (PIE) with air dissecting along the peribronchovascular interstitial sheaths, interlobular septa, visceral pleura and pneumomediastinum.^[5]

In patients with COVID-19, the incidence of pneumomediastinum associated with subcutaneous emphysema is 13%;^[6] however, the incidence of PIE is not reported.

We report chest CT findings of PIE, its incidence and complications in patients with COVID-19.

MATERIALS AND METHODS

We retrospectively analyzed 897 consecutive chest CT scans of COVID-19 patients, performed at Santa Maria della Misericordia University Hospital, Perugia, Italy, during the COVID-19 pandemic period from March 2020 to September 2021. The study included 25 patients, 19 men and 6 women, with a mean age of 64 years ± 12 (range, 42–81 years). Chest CT was performed on a 64-section scanners (Optima CT660 GE Healthcare, Siemens Somatom Sensation 64 slice CT) and images were reconstructed in the axial plane using slice thicknesses of 1.0 and 1.25 mm. Two radiologists (M.S. and G.B.S. with 26 and 15 years of experience in chest CT, respectively) and two physicians in training in diagnostic radiology (A.B. and A.B.) independently and in consensus assessed the PIE as air within the perilobular (low-attenuation area) and perivascular interstitium, its complications, parenchymal abnormalities and pleural effusion.

Institutional review board approval was not required since the retrospective nature of the study and since the CT scan was performed as a part of a routine clinical procedure. Written informed consent for data publication was obtained from all patients and their identity was not disclosed in the study.

Descriptive statistics were used to summarize the data, and the results were expressed as counts and percentages.

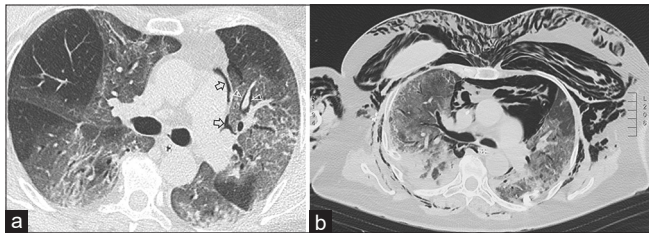


Figure 1: (a) Chest computed tomography, lung window, in a 58-year-old female, obese, COVID-19, shows pulmonary interstitial emphysema in the right upper lobe (head arrows) and pneumomediastinum (arrows) with bilateral ground-glass opacity. (b) Chest computed tomography, lung window, after 10 days, shows massive pneumomediastinum and subcutaneous emphysema, with bilateral ground-glass opacity and consolidation on the right inferior lobe. The patient died after 20 days

RESULTS

Out of 897 consecutive chest CT, PIE was revealed in 25 patients and associated with pneumomediastinum, subcutaneous emphysema, and pneumothorax in 25 (100%), 16 (64%), and 7 (28%), respectively.

Out of 25 patients, ground-glass opacity (GGO) was revealed in 24 patients, crazy paving in 23 patients, consolidation in 22 patients and pleural effusion in 2 patients. Eighteen out of 25 patients had noninvasive ventilation (NIV) before CT scan, initially treated with continuous positive airway pressure (positive end expiratory pressure [PEEP] of 10 cmH₂O) and subsequently with bilevel positive airway pressure (range PEEP of 8–12 cmH₂O).^[6]

Table 1: Pulmonary interstitial emphysema and complications: chest CT findings and clinical characteristics in 25 patients with COVID-19

	Patients, n (%)
PIE and complications	
PIE	25 (100)
Pneumomediastinum	25 (100)
Pneumopericardium	20 (80)
Pneumothorax	7 (28)
Subcutaneous emphysema	16 (64)
Parenchymal lung abnormalities	
GGO	24 (96)
Crazy paving	23 (92)
Consolidation	22 (88)
Pleural effusion	2 (8)
Ventilatory data	
NIV	18 (72)
OTI	7 (28)
Exitus	6 (24)
Arterial blood gas	
pO ₂ (mmHg)	63.5 (75-100)
pCO ₂ (mmHg)	40.7 (35-45)
MetHb (%)	0.9
HHb (%)	7.2
pH	7.459

PIE: pulmonary interstitial emphysema, DAD: Diffuse alveolar damage, GGO: Ground-glass opacity, NIV: Noninvasive ventilation, OTI: Orotracheal intubation

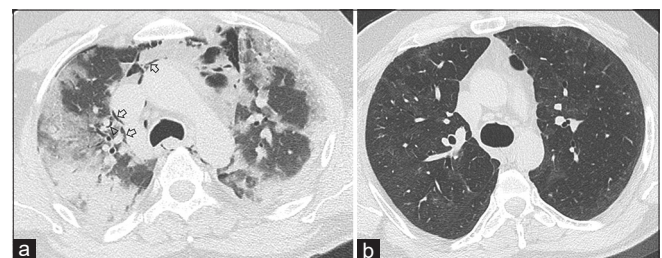


Figure 2: (a) Chest computed tomography, lung window, in a 53-year-old male, COVID-19, shows pulmonary interstitial emphysema in the right upper lobe (head arrows) and pneumomediastinum (arrows) with bilateral ground-glass opacity and consolidation. (b) Chest computed tomography, lung window, after the correction of the ventilation flows and pressures, shows a resolution of pulmonary interstitial emphysema, pneumomediastinum, and bilateral pulmonary abnormalities. The patient was discharged after 25 days of hospitalization

The remaining 7 patients had invasive mechanical ventilation via orotracheal intubation (pressure plateau at approximately 25 cmH₂O). Six out of 25 (24%) patients died.

Representative cases of PIE with complication and resolution are shown in Figures 1 and 2, respectively. CT findings and relevant clinical characteristics of PIE and complications in 25 patients with COVID-19 are summarized in Table 1.

DISCUSSION

The incidence of PIE found in our series is 2.8%. PIE was associated with pneumomediastinum in 25 out of 25 patients (100%), pneumopericardium in 20 out of 25 patients (80%), subcutaneous emphysema in 16 out of 25 patients (64%), and pneumothorax in 7 out of 25 patients (28%).

GGO represents the most frequent parenchymal abnormalities and occurs in 24 out of 25 cases (96%). In all patients, tidal volume was in line with the guidelines;^[7] 72% had NIV and 28% mechanical ventilation.

Hence, it can be assumed that alveolar rupture and subsequent PIE, according to others,^[5] may be due to an increase in the frailty of the alveolar wall induced by COVID-19 more than barotrauma; the pressure is not necessarily as high as in invasive mechanical ventilation, due to both NIV (PEEP <30 cm of H₂O) and a probable redistribution of ventilation towards the pulmonary apex (the mid-low regions of the lung are typically affected by lung abnormalities related to COVID-19).

In conclusion, chest CT is the imaging modality of choice in detecting PIE, complications, and associated parenchymal abnormalities in COVID-19. The timely detection of PIE and minimal pneumomediastinum could aid the optimization of ventilation modalities and parameters based on patients clinical status and potentially reduce the complications.

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Conflicts of interest

There are no conflicts of interest.

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