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Case Series / Olgu Serisi

Air leaks in COVID-19 pneumonia

COVID-19 pnömonisinde hava kaçakları

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ABSTRACT

The novel coronavirus infection 2019 (COVID-19), which was first identified in Wuhan, China in December 2019 and caused a pandemic, is mostly survived with mild symptoms, while invasive and non-invasive mechanical ventilation support is required in some patients. Pneumothorax, pneumomediastinum, and subcutaneous emphysema may develop in COVID-19 patients. In this study, cases of pneumothorax, pneumomediastinum, and subcutaneous emphysema in patients who were followed in the intensive care unit with the diagnosis of COVID-19 were evaluated. In conclusion, although rare, these complications can be fatal and increase the severity of the disease, which already has a high mortality rate in the intensive care unit. Early detection and management of these complications can reduce morbidity and mortality.

Keywords: COVID-19, pneumomediastinum, pneumothorax, subcutaneous emphysema.

ÖZ

Çin'in Wuhan kentinde 2019 yılının Aralık ayında ilk kez tanımlanmış ve pandemiye neden olmuş olan yeni koronavirüs enfeksiyonu 2019 (COVID-19), çoğunlukla ayakta ve hafif semptomlarla atlatılırken, bir kısım hastada invaziv ve noninvaziv mekanik ventilasyon desteği gerekli olmaktadır. COVID-19 hastalarında pnömotoraks, pnömomediastinum ve cilt altı amfizem gelişebilir. Bu çalışmada, COVID-19 tanısı ile yoğun bakım ünitesinde takip edilen hastalarda gelişen pnömotoraks, pnömomediastinum ve cilt altı amfizem olguları incelendi. Sonuç olarak, nadir görülmekle birlikte, bu komplikasyonlar ölümcül seyredebilir ve zaten yüksek yoğun bakım mortalitesi olan hastalığın ciddiyetini artırabilir. Bu komplikasyonların erken dönemde saptanması ve yönetimi ile morbidite ve mortalite azaltılabilir.

Anahtar sözcükler: COVID-19, pnömomediastinum, pnömotoraks, cilt altı amfizem.

The novel coronavirus infection (COVID-19), which was identified for the first time in December 2019 in Wuhan, Hubei province of China, spread rapidly all over the world and was defined as a pandemic by the World Health Organization (WHO).

Most of the patients survive the disease standing and with mild symptoms, while some patients die from COVID-19-related multiorgan failure. Invasive and non-invasive mechanical ventilation and respiratory support are widely applied to patients in the intensive care unit (ICU) setting.

In published case reports, pneumothorax, pneumomediastinum and subcutaneous emphysema may develop in some patients who are followed with COVID-19, who are breathing spontaneously or who are mechanically ventilated. In this article, we present cases of pneumothorax, pneumomediastinum and subcutaneous emphysema in patients followed in the COVID-19 ICU.

CASE REPORT

Medical files, radiological images, and reports of a total of 155 patients (99 males, 56 females; mean age: 66.8±14.7 years; range, 24 to 94 years) hospitalized with the diagnosis of COVID-19 from March 19, 2020, when the first case was admitted to the ICU, to June 30, 2020, were retrospectively

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Table 1. Patient characteristics

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7	Patient 8	Patient 9	Patient 10	Patient 11
Age/Sex	60/M	46/F	70/M	32/M	94/M	57/M	75/M	43/M	55/M	71/F	65/F
History of lung disease	-	-	-	-	-	-	-	-	-	-	-
Length of stay (Day)	43	5	5	44	15	16	23	18	14	5	4
Ventilated (Day)	33	5	5	43	13	14	21	17	0	4	3
NIV/NHFO (Day)	0/0	0/0	0/0	0/0	2/0	0/2	2/0	0/0	7/13	1/0	0/0
Radiological findings	Peripheral GGD, right PTX	Diffuse GGD, right PTX	Diffuse GGD, diffuse SE, PM, HPTX	Diffuse GGD, SE, PTX, PM	HPTX, SE, diffuse EC	Diffuse GGD, SE, PTX, PM	Diffuse GGD, SE, minimal PTX, PM	Diffuse GGD, PM	Diffuse GGD, SE, PM	Diffuse GGD, SE	Diffuse GGD, SE
Result	S	NS	NS	NS	NS	NS	NS	NS	S	NS	NS
Airway	T	OI	OI	OI	OI	OI	OI	OI	Spontaneous	OI	OI

NIV: Non-invasive ventilation; NHFO: Nasal high-flow oxygen; GGD: Ground glass density; PTX: Pneumothorax; HPTX: Hydropneumothorax; PM: Pneumomediastinum; SE: Subcutaneous emphysema; EC: Emphysematous changes; S: Survive; NS: Non survive; OI: Orotracheal intubated; T: Tracheostomy.

Table 2. The Day before detection/detection day/after thorax tube

	Patient 1			Patient 2			Patient 3			Patient 4			Patient 5			Patient 6			Patient 7		
Ventilation mode	$O_2$4L/m	PSV	$O_2$6L/m	PCV	PCV	PCV	PCV	PCV	PCV	PCV	PCV	PCV	PSV	PCV	-	PSV	PRVC	PRVC	PACV	PSV	-
P_{Peak} (cmH_2O)	-	15	-	20	23	27	27	28	29	25	25	28	28	28	-	18	33	33	30	29	-
P_{Mean} (cmH_2O)	-	8	-	12	10	15	17	17	21	17	16	21	14	15	-	11	18	17	15	19	-
PEEP (cmH_2O)	-	5	-	8	6	6	7	8	8	8	8	8	10	10	-	10	10	10	15	15	-
VT (mL)	-	430	-	400	280	330	460	480	480	300	360	350	520	450	-	800	530	450	370	510	-
FiO_2 (%)	37	30	45	25	70	100	100	50	50	60	60	70	40	40	-	40	50	50	50	60	-
Frequency (breath/min)	45	40	26	12	30	30	17	21	21	10	22	11	22	39	-	18	35	35	25	12	-
C_{Dyn} (mL/cmH_2O)	-	43	-	33	16	15	23	24	22	17	21	17	28	25	-	100	23	19	24	35	-
PaO_2/FiO_2	178	183	287	340	70	86	151	123	160	123	103	177	200	175	-	218	166	222	256	195	-
HR (bpm)	90	90	90	55	95	120	100	110	87	110	120	120	100	110	-	100	125	120	65	80	-
MAP (mmHg)	60	60	85	95	63	70	90	87	77	90	107	103	80	80	-	92	65	60	110	85	-
Lactate (mmol/L)	1,8	0,9	1,3	2,5	4,8	7,8	5,3	3	2,2	2,6	2,7	1,9	4,9	4,8	-	2,5	2,5	3,2	2,2	2,3	-
Vasopressor therapy	-	-	-	-	N	N	-	N	N	N	-	N	N	N	-	-	N	N, Dob	N	N	-
Sedation	D	D	D	M	-	-	R	P	P	F, M, P, D	F, M, P, D	F, M, P, D	P	P	-	Mor, D	Mor, D	Mor, D	Mor, M	M	-

PSV: Pressure support ventilation; PCV: Pressure control ventilation; PRVC: Pressure regulated volume control; PACV: Pressure assist control ventilation; P_{Peak}: Peak inspiratory pressure; P_{Mean}: Mean airway pressure; PEEP: Positive end expiratory pressure; VT: Tidal volume; FiO_2: Fraction of inspired oxygen; C_{Dyn}: Dynamic compliance; HR: Heart rate; MAP: Mean arterial pressure; D: Dexmedetomidine; M: Midazolame; N: Noradrenalin; Dob: Dobutamine; P: Propofol; Mor: Morphine.

analyzed. Retrospective file evaluation revealed pneumothorax in two patients, pneumothorax, pneumomediastinum and subcutaneous emphysema in four patients, pneumothorax and subcutaneous emphysema in one patient, pneumomediastinum in one patient, pneumomediastinum and subcutaneous emphysema in one patient, and only subcutaneous emphysema in two patients. While pneumothorax was seen with a frequency of 4.51%, pneumomediastinum was seen with a frequency of 3.87% and subcutaneous emphysema was found with a frequency of 5.16%.

Age, sex, length of stay in the ICU, duration of respiratory support, radiological findings and survival status of the patients were recorded (Table 1). If a thoracic tube was used in patients with pneumothorax, previous and subsequent ventilation, oxygenation and hemodynamic data were recorded (Table 2).

None of the patients had a history of lung disease prior to COVID-19. All of the patients were hospitalized in the ICU due to respiratory failure caused by COVID-19, and all of them had diffuse ground glass densities on thoracic computed tomography (CT) scans. The length of stay ranged from 4 to 44 days. Non-invasive mechanical ventilation and nasal high-flow oxygen therapy (HFOT) were also applied to selected patients whose days of invasive mechanical ventilation ranged from 0 to 43.

Mechanical ventilation data, partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FiO_2), heart rate, mean arterial pressure, lactate, vasopressor and sedation data were recorded on the day of detection of patients with pneumothorax, the day before detection, and after the thoracic tube was inserted (Table 2).

The peak inspiratory pressure (PIP) of the patients who developed pneumothorax on the previous day was between 18 and 30 cmH_2O, mean airway pressure (MAP) was between 11 and 17 cmH_2O and positive end-expiratory pressure (PEEP) between 7 and 15 cmH_2O. One patient was breathing spontaneously from the tracheostomy, three patients were ventilated with pressure control ventilation (PCV) mode, two patients with pressure support ventilation (PSV) mode, and one patient with pressure assist-control ventilation (PACV) mode.

Any of pneumothorax, pneumomediastinum, subcutaneous emphysema (Figure 1a-c) was developed in one of the spontaneously breathing, nine patients orotracheal intubated, and one tracheostomized patient. All patients were consulted with thoracic surgery. In line with the surgeons' recommendations, daily chest radiographs were taken for the follow-up of pneumothorax. A thoracic tube was inserted in the patients who showed progress in the pneumothorax according to the radiographs, and follow-up was recommended for patients with minimal pneumothorax and no progress in pneumothorax. In five of seven patients with pneumothorax, thoracic tube was inserted and underwater drainage was performed by the thoracic surgery specialists. The underwater drainage system of patients with concomitant pneumomediastinum or subcutaneous emphysema was connected to a vacuum aspirator, no drainage was applied to patients who did not develop pneumothorax and follow-up was recommended. One of the two patients with pneumomediastinum without pneumothorax was never intubated, received seven days NIV and 13 days NHFO treatments. While applying NIV, PEEP was limited to 5 cmH_2O, delta P to 10 cmH_2O. The other patient was intubated, when pneumomediastinum developed and lung protective ventilation was continued.

One of the patients with pneumothorax whose lung expanded transferred to the service after a period of

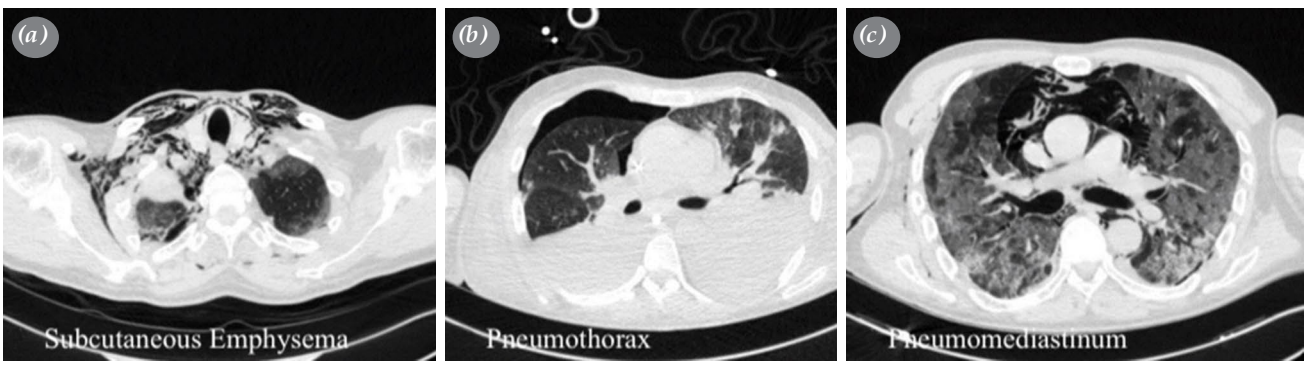

Figure 1. Types of air leaks seen in COVID-19 pneumonia.

removal of the thorax tube. A patient who developed pneumomediastinum and subcutaneous emphysema and followed up with non-invasive ventilation (NIV) and NHFO in spontaneous breathing was transferred to the service after respiratory failure findings disappeared. The other nine patients died during the ICU stay.

DISCUSSION

The infection of COVID-19 has caused and would continue to have significant consequences in all areas of the world in the approximately seven-month period, since it was first detected. One of the major hits is on the healthcare systems. Although mortality rates are very low compared to previous coronavirus outbreaks, its rapid spread has caused the healthcare system in many countries to become locked and unable to take care of patients with other diseases.

The virus that causes COVID-19 infection enters the cells by binding to angiotensin converting enzyme-2 (ACE2) receptors in the human body. As a result of the cytokine storm it creates, it can show a course that progresses to multiorgan failure and may result in death. About 1.1% of active cases on July 24th, 2020 were reported as critical patients.[1] Intensive care hospitalization rates from Italy were around 16%.[2] In many patients, the respiratory system is mainly affected.[3] Patients who develop respiratory failure and are admitted to the ICU follow-up are treated with invasive and non-invasive mechanical ventilation and NHFO.

Pneumothorax and pneumomediastinum can be defined as the alveolar air reaching the intrapleural space and mediastinum by crossing the alveolar wall. It can occur as a complication of mechanical ventilation, or it can occur spontaneously or iatrogenically in the course of a disease.

Pneumothorax and pneumomediastinum are rare imaging findings in COVID-19.[4] It has been reported with case reports and case series, since the beginning of the outbreak that it may occur spontaneously or after intubation in the course of the disease.[5-8] These patients can be detected, when they present to the emergency department with sudden respiratory distress, as well as in patients undergoing invasive or non-invasive mechanical ventilation in the ICU.[7,9] The variety of cases suggests that the mechanism of its occurrence is not only barotrauma due to mechanical ventilation, but also COVID-19 itself may predispose to pneumothorax or pneumomediastinum.

It has been reported in previous studies that pneumothorax, which is a rare complication, is detected around 1 to 2% in the course of COVID-19.[4,10] In the literature, the frequency of pneumothorax in COVID-19 patients hospitalized in the ICU is reported to be around 0.54 to 2%.[9] There are similar results in recent studies such as ours for spontaneous pneumomediastinum in mechanical ventilated patients.[11,12] The reason for the higher frequency of pneumothorax in our single-center retrospective study may be the fact that a larger patient group was scanned. In addition, the course and severity of the disease are very variable, and the factors determining this have not been revealed, yet. Barotrauma is proposed as the mechanism responsible for pneumothorax in intubated patients. Lung-protective ventilation methods are recommended for all acute respiratory distress syndrome patients. These recommendations are to limit the plateau pressure to 30 cmH_2O, the driving pressure to 15 cmH_2O, and the tidal volume to 6 mL/kg (ideal body weight).[13] These limitations are also recommended for COVID-19 patients. Plateau pressures were kept below 30 cmH_2O in these patients. Therefore, barotrauma was not considered as the primary mechanism responsible for pneumothorax or pneumomediastinum.

One of the mechanisms of pneumomediastinum and pneumothorax is the sudden increase in intrathoracic pressure and, consequently, perforation of the alveolar wall.[14] Possible overdistention of the alveoli using mechanical ventilation may put patients at risk for the development of pneumothorax.[15] Dry cough is a very common COVID-19 symptom, and we believe that it can tend to air leakage in the infected tissue with increased intrathoracic pressure.[9]

Prolonged coughing is a possible triggering factor which is common symptom of COVID-19 pneumonia.[10] Cough may enhance leakage of air out of the alveoli by causing sudden lengthening and shortening of the pulmonary vessels and associated bronchi during respiration and further moving the bubbles along the vascular sheaths.[16] Overdistension due to mucus impaction and/or inflammation may occur in aveoli and increase the risk of spontaneous pneumothorax.[15]

In conclusion, although rare, such complications may have serious consequences and even have a fatal course, increasing the severity of the condition of patients with already high ICU mortality. More careful adjustment of the mechanical ventilator, adherence to

the established pressure limits, and attention to the antitussive treatment of patients with intense cough can protect the patients from these complications. Early detection and management of these complications can reduce morbidity and mortality.

Patient Consent for Publication: A written informed consent was obtained from each patient.

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