Case Report

Pneumomediastinum and Spontaneous Subcutaneous Emphysema in COVID-19 Patients Using High-Flow Nasal Cannula (HFNC)

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Abstract

Background: Spontaneous pneumothorax, pneumomediastinum, and subcutaneous emphysema are rare complications that occur without mechanical ventilation, namely 0.81% of all COVID-19 patients. During the COVID-19 pandemic, high-flow nasal cannulas (HFNC) were used to support respiratory failure in critically ill patients. However, there have been no clinical trials explaining its safety and effectiveness. Hypoxemic normocapnic respiratory failure is an indicator of HFNC use. This study reports a case of associated spontaneous subcutaneous pneumomediastinum and emphysema in a COVID-19 patient using HFNC.

Case: A 30-year-old male patient came to the hospital with a chief complaint of increasingly severe shortness of breath and confirmed COVID-19. Physical examination revealed a good airway, spontaneous breathing with a frequency of 28 times/minute; SpO_2 of 97% with HFNC Flow 60 and FiO_2 60%; blood pressure of 102/69 mmHg; and heart rate of 65 beats per minute. On the second day of treatment in the ICU, the patient did not experience desaturation or hypotension. Patent airway, spontaneous breathing, and oxygenation initiated using NRM 10lpm with a target SpO_2 of 97%, RR at 30-32x/minute. On the fifth day, desaturation and hypotension were no longer observed.

Discussion: Real-Time Reverse Transcriptase (RT)–PCR Diagnostic Panel detects SARS-CoV-2 in respiratory samples. Chest CT scans show viral pneumonia. Subcutaneous emphysema (SE) and pneumomediastinum cause breathing issues. Severe COVID-19 is treated with antivirals, vitamins, and oxygen therapy. Pneumomediastinum or subcutaneous emphysema may occur due to prolonged non-invasive ventilation but is generally self-limited.

Conclusion: Clinical improvement was found in COVID-19 patients with pneumomediastinum and spontaneous subcutaneous emphysema using HFNC.

Keywords: high flow nasal cannula, pneumomediastinum, spontaneous subcutaneous emphysema

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INTRODUCTION

COVID-19 is an emerging infectious disease caused by a new coronavirus called SARS-CoV2.[1] Acute respiratory distress syndrome (ARDS) is a major and fatal complication with an incidence in 41% of hospitalized COVID-19 patients.[2] Based on data from John Hopkins Hospital, on April 14, 2022, about 501,512,915 cases of COVID-19 were found worldwide and caused 6,188,577 deaths.[3] Based on the distribution data of the Ministry of Health in Indonesia as of April 13, 2022, a total of 6,036,909 positive cases of COVID-19 were found in Indonesia with 155,746 recorded deaths.[4]

Recent studies show that there is a rare occurrence of spontaneous pneumothorax, pneumomediastinum, and subcutaneous emphysema in COVID-19 patients who have not undergone mechanical ventilation. The incidence of these complications is estimated to be around 0.81%.[5]

Mechanical ventilation, particularly when high positive end-expiratory pressure (PEEP) is used, can result in pulmonary barotrauma. This condition increases the risk of pneumomediastinum and pneumopericardium. When high intra-alveolar pressure is maintained, it can cause the alveoli to rupture, causing air to dissect along the bronchovascular sheath towards the mediastinum..[2]

The incidence of subcutaneous emphysema and spontaneous pneumomediastinum is extremely rare in the general population (1.2 and 3.0 per 100,000, respectively).[6] Pneumomediastinum can be divided into spontaneous pneumomediastinum

and secondary pneumomediastinum. Spontaneous pneumomediastinum can be caused primarily by tobacco and recreational drug use. Common symptoms of pneumomediastinum are tightness, retrosternal chest pain, and coughing. The diagnosis is confirmed by a chest X-ray (CXR), which shows signs of radiolucent lines and bubbles in and around the mediastinum. In addition, a chest CT scan could be used to evaluate the severity of the pneumomediastinum.[7]

A high-flow nasal cannula (HFNC) is a ventilation support capable of providing a high flow of optimally heated and humidified air. This method can distribute oxygen effectively and allows an increase in the fraction of inhaled oxygen (FiO_2), from 21% to almost 100%, to prevent oxygen dilution with room air.[1]

High-flow nasal cannula can produce FiO_2 of up to 100%. The use of HFNC in patients with acute respiratory failure or ARDS results in lower positive pressure in the upper airway and an increased PEEP effect. Another physiological effect of HFNC is to reduce respiratory rates and improve diffusion. The use of HFNC has been shown to reduce the need for mechanical ventilation and reduce mortality in ARDS patients in the ICU.[8]

During the COVID-19 pandemic, HFNCs were used to support respiratory failure in critically ill patients. However, there have been no clinical trials explaining its safety and effectiveness. Hypoxemic normocapnic respiratory failure is an indicator of HFNC use. Pneumomediastinum and pneumothorax are not currently indicators of the use of HFNC. Baudin et al described 177 episodes of HFNC involving 145 subjects.[9]

Among this population, six subjects with a history of pneumothorax (3%) were identified before initiating HFNC, and no worsening condition occurred after HFNC use. However, we observed two episodes (1%) of new pneumothorax.[1] HFNC results in increased positive pressure within the airways, potentially causing air leaks. We found radiological evidence of spontaneous air leaks in six patients with an onset of 10.33±1.86. Two of the six patients required intubation, but all pneumomediastinum/pneumothorax events occurred before intubation.[9]

CASE

A 30-year-old male patient came to the hospital with a chief complaint of increasingly severe shortness of breath. He also complained of coughing containing phlegm since six days before hospital admission, and the phlegm was difficult to expel. The cough was getting severe one day before hospital admission; the complaint was accompanied by fever and shortness of breath.

Table 1. Patient Laboratory Examination

Inspection	17/06/2021	20/06/2021
White Blood Cells	**7,540***	**12,530**
Hb	13.2	13.2
Hematocrit	39%	39.3%
PLT	335,000	397,000
MCV	77.8	78.8
MCH	26.6	26.5
MCHC	34.2	33.6
Eosinophil	0.00%	1%
Basophil	0.00%	0.1%
Neutrophil	79.20%	83%
Neutrophil Absolute	**5970***	10,460
Lymphocytes	11.90%	9.9%
absolute lymphocytes	**900***	1240
monocytes	8.9	690
NLR	6.63	8.44
Fibrinogen	**514.4***	361.9
D dimer	0.39	1.73
LDH	461	1.1
Quantitative C-Reactive Protein	5.9	6.1
Ferritin	**983.7***	0.06
Calcium	8.5	---
ELISA	Reactive (COI 9.45)	---
Antigen swabs	**POSITIVE***	---
BGA Artery/Vena	Arteries	Arteries
pH	7.35	7.43
pCO2	31.2	29.2
pO2	120.8	64.5
HCO3	17.3	19.4
BE	-8.6	-5.1
O2 saturation	98.20%	92.70%
Hb	12.9	12.7
Lactate	2.4	---

On physical examination, it was observed that the airway was clear, spontaneous breathing with a frequency of 28 times/minute, SpO2 of 97% with

HFNC Flow 60 and FiO2 60%, blood pressure of 102/69 mmHg, heart rate of 65 beats per minute, GCS of E4V5M6, fluid balance of 280cc/24 hours. Distention, residue, edema, and cyanosis were not found.

On assessment, the patient was diagnosed as having severe confirmed COVID-19 pneumonia in the critical illness and severe ARDS. In the treatment plan, the patient was given oxygen ventilation using HFNC while being evaluated and treated in the HCU room. After the second day in the HCU, the patient felt that the condition was getting tighter, the SpO_2 decreased to 94%, followed by complaints of headaches and neck pain. We assessed the clinical evaluation, ROX Index, and CXR, then consulted the patient for ICU care.

The patient was then transferred to the ICU with worsening shortness of breath, chest pain, and neck pain. Physical examination revealed a clear airway, spontaneous breathing with a frequency of 30 breaths/minute, 97% SpO_2 with HFNC Flow 40 FiO_2 60%, blood pressure of 100/59 mmHg, heart rate of 67 beats per minute, with the additional diagnosis of subcutaneous emphysema. Chest CT scan confirmed the pneumomediastinum. The treatment plan carried out in the ICU was for HFNC weaning, then switched to NRM. The antigen swab examination was positive. Laboratory tests are listed in Table 1.

Examination of the CXR after HFNC oxygenation and drugs administration is shown in Figure 1. On the second day of treatment in the ICU, the patient did not experience desaturation or hypotension. Patent airway, spontaneous breathing, and oxygenation were initiated using NRM at 10lpm with a target SpO_2 of 97% and RR at 30–32x/min. Blood pressure was 118/78 mmHg and heart rate was 92x/minute.

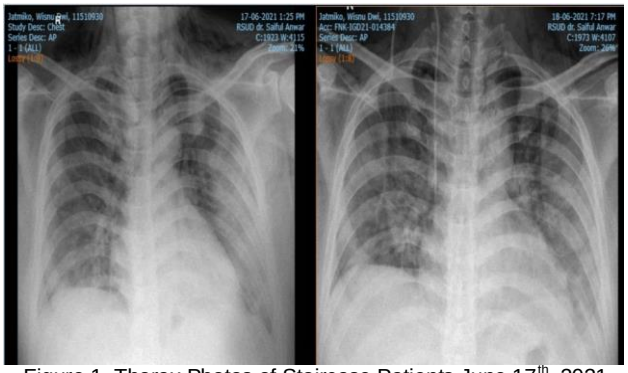

Figure 1. Thorax Photos of Staircase Patients June 17th, 2021 and June 18th, 2021

On the fifth day, there were no more desaturation and hypotension. Patent airway, spontaneous breathing, NRM 10lpm with a target SpO_2 of 98%, RR 30–32x/minute. Blood pressure was stable at 110/67 mmHg and heart rate was normal at 95x/minute. Urine production was 1,000cc/14 hours with a fluid balance of about 365cc/14 hours.

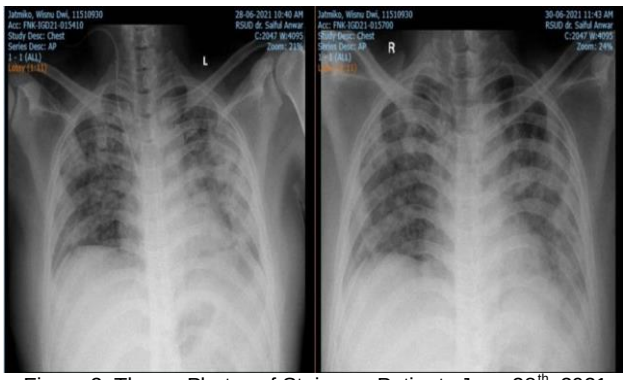

Figure 2. Thorax Photos of Staircase Patients June 28th, 2021 and June 30th, 2021

Table 2. Examination of Clinical Presentation Parameters

Parameters of clinical percentage	Hospital Admission	ICU Admission	First Treatment Day	Third Treatment Day	Fifth Day of Care (transfer from ICU)
Clinical	Cough(+), fever(+), shortness of breath (+)	The tightness is getting worse(+), headache(+), Neck pain(+)	Shortness of breath(+) reduced, neck pain(+) reduced	Shortness of breath(-), neck pain(-)	No complaints
Blood pressure	102/69mmHg	100/59mmHg	118/78mmHg	119/73 mmHg	120/70 mmHg
HR	65x/minute	67x/minute	92x/minute	60 x/minute	68x/minute
RR	28x/min	30x/minute	26x/minute	24x/minute	22x/minute
HFNC Flow	60	60	40	---	---
FiO_2	60%	60%	60%	---	---
SpO_2	97%	94%	97%	98%	98%
ROx Index	6.2	---	---	7.0	---

The situation improved and clinical evaluation and ROx Index were carried out with plans to switch oxygenation from NRM to simple mask and transfer to a regular ward. The subcutaneous emphysema disappeared on day 4, so the patient was transferred to a regular ward. During hospitalization, the patient was treated with remdesivir, dexamethasone, and enoxaparin.

DISCUSSION

One of the main methods for detecting SARS-CoV-2 in upper and lower respiratory tract specimens is the Real-Time Reverse Transcriptase (RT)–PCR Diagnostic Panel. Swabs were taken on days 1 and 2 for diagnosis. If the examination on the first day is positive, there is no need for another examination on the second day. If the examination on the first day is negative, it is necessary to examine on the following day (second day). Chest CT scans in patients with COVID-19 most frequently showed ground-glass opacification (56.4%), consistent with viral pneumonia, with or without consolidation abnormalities.[10]

Subcutaneous emphysema (SE) and pneumomediastinum are conditions in which there is air in the subcutaneous tissue and mediastinum, respectively. Most patients experienced mild hypoxia, but initial vital signs were stable. Symptoms are nonspecific and mostly respiratory, with the main symptom being dyspnea.[11]

Clinical manifestations of MSS can include retrosternal chest pain worsened by deep breathing and coughing, progressive dyspnea or shortness of breath, dysphagia or difficulty swallowing, and neck pain. However, some patients may not have any symptoms.Physical examination reveals crepitation in the cervical region on auscultation (Hamman's sign) and palpation, especially with concomitant subcutaneous emphysema. Vital signs may show tachycardia, tachypnea, or hypotension. The SPM can be visualized on chest CT.[12] Our patient had a main complaint of shortness of breath that was getting worse. When transferred to the ICU, the patient complained of worsening shortness of breath, headache, and neck pain.

A treatment protocol has been suggested for patients with severe COVID-19. The protocol involves administering vitamin C, preferably 200-400 mg/8 hours in 100cc of 0.9% NaCl discharged in 1 hour, given intravenously (IV) during treatment. Additionally, vitamin B1, 1 ampoule/24 hours intravenously, and vitamin D in supplement form is recommended. The suggested dose for vitamin D is between 400-1000 IU per day, available as tablets, capsules, effervescent tablets, chewable tablets, lozenges, soft capsules, powder, or syrup. Alternatively, 1000-5000 IU per day is also recommended, which is available as 1000 IU tablets and 5000 IU chewable tablets. If there is a suspicion of a sepsis condition being caused by bacterial co-infection, the antibiotics selected should be based on the patient's clinical condition, the source of the infection, and any risk factors present. It's important to perform blood cultures and consider sputum cultures (with special care).[13]

Antivirals that can be given are favipiravir (dose 200 mg) loading dose 1600 mg/12 hours/orally on the first day then 2 x 600 mg (days 2-5), OR Molnupiravir (dose 200 mg, orally), 400 mg/12 hours, for five days, OR Nirmatrelvir/Ritonavir (Paxlovid) (150 mg/100 mg in combination), Nirmatrelvir 2 tablets every 12 hours, Ritonavir 1 tablet every 12 hours, given for five days, OR Remdesivir 200 mg IV drip (day 1) followed by 1x100 mg IV drip (day 2-5 or day 2-10) according to drug availability in each health facility. Dexamethasone at a dose of 6 mg/24 hours for ten days or other equivalent corticosteroids such as methylprednisolone 32 mg or hydrocortisone 160 mg in severe cases receiving oxygen therapy or severe cases using a ventilator.

Hospitalized patients with moderate or severe COVID-19 are considered to receive a standard dose of LMWH 1x0.4cc subcutaneously or UFH 5,000 units twice daily. Enoxaparin can be given by injection subcutaneously of 2000 anti-Xa IU/0.2 mL (20 mg), 4000 anti-Xa IU/0.4 mL (40 mg), or 6000 anti-Xa IU/0.6 mL (60 mg).

Oxygen therapy is the mainstay of treatment and can be administered through an oxygen mask, non-invasive ventilation, including HFNC, bilevel positive airway pressure (BiPAP), and in severe cases via invasive ventilation. Severe COVID-19 often progresses to acute hypoxemic respiratory failure, requiring high concentrations of FiO_2. HFNC is a strategy to improve oxygenation and carbon dioxide clearance. HFNC is currently the first choice for critical COVID-19 patients. The use of HFNC can reduce the need for mechanical ventilation.[13,14]

Pneumomediastinum and subcutaneous emphysema are generally benign and self-limited conditions. Management of pneumomediastinum is nonspecific and generally involves symptomatic treatment. Oxygen therapy is administered to increase free air resorption in the secondary mediastinum with higher nitrogen concentrations. Follow-up treatment for COVID-19 is also important because the virus can continue to destroy type II pneumocytes in the lungs, thereby damaging the alveolar membranes.[13,14]

Pneumomediastinum or subcutaneous emphysema may be associated with prolonged non-invasive ventilation as a sequela of COVID-19. However, pneumomediastinum and subcutaneous emphysema are generally benign and self-limited conditions.

LIMITATIONS

It is important to acknowledge that this case report does have certain limitations. Firstly, due to the absence of a CT scan of the chest, a definitive definition of the lesion and potential Macklin effect could not be determined. Furthermore, the constantly evolving treatment protocols for this novel disease also presented a limitation for this study. However, despite these constraints, this research offers valuable insights into the complexities of COVID-19 and its associated complications.

CONCLUSION

Increased alveolar pressure and diffuse alveolar injury are pathognomonic of COVID-19 pneumonia. This makes the alveoli more susceptible to rupture, especially in patients with a severe cough. The alveolar rupture causes pneumomediastinum via the Macklin phenomenon. HFNC has the potential to generate an increase in positive pressure within the airways, which could potentially lead to air leakage. Pneumomediastinum or subcutaneous emphysema may be associated as a sequela of COVID-19 with prolonged non-invasive ventilation. However, pneumomediastinum and subcutaneous emphysema are generally benign and self-limited conditions. Management of pneumomediastinum is non-specific and generally involves symptomatic treatment.

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