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**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 which 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 Report:** A 30-year-old male patient came to the hospital with a chief complaint of increasingly severe shortness of breath and a confirmed COVID-19. Physical examination revealed a good airway, 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; 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 inisiated using NRM 10lpm with a target SpO2 of 97%, RR at 30-32x/minute. On the fifth day, desaturation and hypotension were no longer observed.  **Conclusion:** Clinical improvement was found in COVID-19 patients with pneumomediastinum and spontaneous subcutaneous emphysema using HFNC.  **Keywords:** pneumomediastinum, spontaneous subcutaneous emphysema, high flow nasal cannula | **Corresponding Author:**  *Rizki Suhadayanti* | Resident of the Department of Anesthesiology and Intensive Therapy, Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia / Dr. Saiful Anwar General Regional Hospital, Malang, Indonesia | suhadayanti.rizki@gmail.com  **Submitted:** March 29th, 2023  **Accepted:** January 5th, 2024  **Published:** April 30th, 2024  **J Respirol Indones. 2024**  **Vol. 44 No. 2: 150-160**  <https://doi.org/10.36497/respirsci.v1i2.20> |

**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

Spontaneous pneumothorax, pneumomediastinum, and subcutaneous emphysema are rare complications that occur without mechanical ventilation in 0.81% of all COVID-19 patients.5 Pulmonary barotrauma due to mechanical ventilation, especially with high positive end-expiratory pressure (PEEP), is a risk factor for pneumomediastinum and pneumopericardium. High intra-alveolar pressure makes the alveoli vulnerable to rupture, allowing air to be dissected along the bronchovascular sheath toward 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, mainly caused by tobacco and recreational drug use; and secondary pneumomediastinum. 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 (FiO2), from 21% to almost 100%, to prevent oxygen dilution with room air.1 HFNC can produce FiO2 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. Among this population, six subjects with a history of pneumothorax (3%) were identified before initiating HFNC, and no worsening condtition 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 REPORT**

A 30-year-old male patient came to the hospital with a chief complaint of increasingly severe shortness of breath. He also complained 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. 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 of 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 SpO2 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% SpO2 with HFNC Flow 40 FiO2 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 below.

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 | 17/06/21 | 20/06/21 |
| 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 |  |

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 |  |  |
| FiO2 | 60% | 60% | 60% |  |  |
| SpO2 | 97% | 94% | 97% | 98% | 98% |
| ROx Index | 6.2 |  |  | 7.0 |  |

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 SpO2 of 97% and RR at 30-32x/min. Blood pressure was 118/78 mmHg and heart rate was 92x/minute. On the fifth day, there were no more desaturation and hypotension. Patent airway, spontaneous breathing, NRM 10lpm with a target SpO2 of 98%, RR 30-32x/minute. Blood pressure was stable in 110/67 mmHg and heart rate was normal in 95x/minute. Urine production was 1000 cc/14 hours with a fluid balance of about 365 cc/14 hours. 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 regular ward. During hospitalization, the patient was treated with remdesivir, dexamethasone, and enoxaparin.

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

X-ray of a person's chest

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

**DISCUSSION**

One of the main methods for detecting the 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 carry out an examination 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.11

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 in nature, with the main symptom being dyspnea.12 Clinical manifestations of MSS include retrosternal chest pain exacerbated by deep breathing and coughing, progressive dyspnea, dysphagia, or neck pain, but some patients may be asymptomatic. 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.13Our 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.

Treatment protocol for patients with severe COVID-19 is the administration of vitamin C 200-400 mg/8 hours in 100 cc of 0.9% NaCl discharged in 1 hour given intravenously (IV) during treatment, vitamin B1 1 ampoule/24 hours intravenously, and vitamin D in supplement form: 400 IU-1000 IU/day (available as tablets, capsules, effervescent tablets, chewable tablets, lozenges, soft capsules, powder, syrup) or 1000-5000 IU/day (available as 1000 IU tablets and 5000 IU chewable tablets). Suppose there is a sepsis condition that is strongly suspected to be caused by bacterial co-infection. In this case, the selection of antibiotics is adjusted to the clinical condition, the focus of infection, and risk factors existing in the patient. Blood cultures should be performed, and sputum cultures (with special care) should be considered.14

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 1x0.4 cc 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 FiO2. 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. 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.14,15

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

The limitations of this case report was the absence of CT scan chest which would have clearly defined the lesion and Macklin effect, if any. Besides that actively evolving treatment protocols of a new disease was also one of the limitation of this study. However despite these limitations, this study adds to existing knowledge about COVID-19 and its complication.

**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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