Case Report
COVID-19 in a Patient Previously Exposed to Toxic Disinfectant from a Humidifier

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ABSTRACT
In August, 2011, the Korean Public Health Surveillance declared an outbreak of pulmonary disease due to the inhalation of humidifier disinfectants (HDs), which led to approximately 20,000 deaths. In March, 2020, the World Health Organization declared coronavirus disease-2019 (COVID-19) a pandemic. In this Case Report, we present a rare case of a patient who inhaled toxic HDs and developed COVID-19. He was young and had a low risk of severe COVID-19, however, he had a critical course to recovery. He was admitted to the intensive care unit and administered high-flow oxygen via a nasal cannula. He received dexamethasone injections each day for 10 days and his condition began to improve on hospital Day 6, although radiographical findings revealed no improvement. He was discharged on hospital Day 26. Despite the patient’s chronic lung disease becoming asymptomatic, HDs could be an important risk factor affecting the clinical course of COVID-19.

Keywords: COVID-19, disinfectant, humidifier, lung diseases, risk factors

Introduction

In the Republic of Korea, an outbreak of pulmonary disease was declared on August 31, 2011, by the Public Health Surveillance [1]. The pulmonary disease was caused by the inhalation of humidifier disinfectants (HDs) which were sold between 1998 and 2011. There were more than 950,000 victims, with an estimated 20,000 deaths [1].

An outbreak of a respiratory disease caused by severe acute respiratory syndrome coronavirus-2 (coronavirus disease-2019 [COVID-19]) led to a pandemic being declared on March 11, 2020, by the World Health Organization. Initial chest computed tomography (CT) scan results of COVID-19 patients who are admitted, present as bilateral, multilobar ground-glass opacity (GGO) with peripheral or posterior distribution (or both) mainly in the lower lobes [2]. The overall probability of progression to critical disease is reportedly 5% which is defined as respiratory failure, septic shock and/or multiple organ dysfunction, and/or ICU admission [3]. However, critical disease differs according to age and its severity and mortality tend to increase with advanced age [3,4]. In addition to age, other risk factors can worsen the disease, one of which is chronic lung disease (CLD) [5,6].

There are very few reports of individuals who have experienced both pulmonary disease caused by the inhalation of HDs and COVID-19. We report a case of a patient who was 45-years-old, and was young enough to have a low incidence of critical disease, but whose condition critically deteriorated due to pulmonary disease caused by inhalation of HDs, which affected the course of COVID-19. This Case Report was approved by the Institutional Review Board (no.: NMC-2021-04-041), and informed consent was obtained from the patient.

Case Report

A 45-year-old Korean man, who was working as a Ukrainian dispatch, experienced symptoms of fever and dyspnea 2 weeks
prior to admission. As the patient's symptoms worsened, a real-time polymerase chain reaction for COVID-19 was performed, which yielded a positive result 2 days before admission. The patient was transported back to Korea on a private plane owned by the company that he worked for. At the airport, the patient was directly transferred to the ambulance and moved to an isolated intensive care unit for infection at the hospital. During the transfer, 7 L/min of oxygen was administered through a nasal cannula. The patient showed a poor general appearance and had severe dyspnea.

The patient had HD-associated lung injury (HDALI) which had caused fibrosis for 10 years and was treated regularly in the Department of Respiratory Medicine before becoming infected with COVID-19. He had a 20-pack-year smoking history which ceased at the time of diagnosis of lung injury. There was no other disease history that the Centers for Disease Control and Prevention suggested was associated with disease progression [6]. His symptoms of HDALI eventually improved, his radiology results were practically clear, and he did not experience difficulties in performing daily living activities.

Upon arrival, his blood pressure, pulse rate, and arterial oxygen saturation were 122/59 mmHg, 84/min, and 78%, respectively. High-flow nasal cannula (HFNC) oxygen therapy was administered at a flow rate of 60 L/min, a fraction of inspired oxygen (FiO₂) of 1.0, and an oxygen flow rate of 15 L/min were simultaneously delivered via a non-rebreather mask because the patient was mouth breathing due to severe dyspnea. After applying oxygen, arterial blood gas analysis (ABGA) was performed and results for the partial pressure of carbon dioxide (pCO₂) was 38.8 mmHg, partial pressure of oxygen (pO₂) was 67.6 mmHg, and arterial oxygen saturation (SaO₂) was 93.2%. Results of the initial laboratory tests were hemoglobin 14.3 g/dL, white blood cells 13,300/μL, platelets 563,000/μL, lactate dehydrogenase 480 U/L, γ-glutamyl transpeptidase 144 U/L, C-reactive protein 48.5 mg/L, aspartate transaminase 41 U/L, alanine aminotransferase 175 U/L, and creatinine 0.6 mg/dL. Procalcitonin rose to 0.05 ng/mL and myoglobin 115.7 ng/mL, while creatine kinase muscle brain and troponin 1 were 0.8 and <0.10 ng/mL, respectively, and within normal range.

In 2015, CT was performed because the patient experienced severe symptoms of HDALI and showed multifocal GGOs with bubble-like lucency and air cysts in both lungs. In 2018, when the patient's symptoms and radiographical findings showed improvement, a repeat CT scan was performed and showed decreased multifocal patchy GGOs in both lungs (Figure 1).

Initial chest radiography performed after admission for COVID-19 treatment showed infiltrations in both lungs, and further radiographical findings revealed no improvement after 10 days. Twenty-six days after admission just prior to hospital discharge, chest radiography showed improvement in the patient's lung condition (Figure 2).

Dexamethasone (6 mg) was injected intravenously once a day for 10 days and eventually reduced to 3 mg intravenously once daily. Afterwards, the treatment was switched to oral methylprednisolone, administered at a dose of 6 mg. During the hospitalization period, no other medications, other than dexamethasone, were used for the treatment of COVID-19.

The patient remained on HFNC oxygen therapy with a non-rebreather mask while in the ICU and on Day 3, ABGA results were pCO₂ 41.8 mmHg, pO₂ 68.3 mmHg, and SaO₂ 93.5% which were obtained whilst on HFNC oxygen therapy. On Day 6 of hospitalization, the patient was transferred to the isolation ward. The ABGA results were pCO₂ 41.2 mmHg, pO₂ 107 mmHg, and SaO₂ 97.9%, and the HFNC oxygen flow rate was reduced to 30 L/min, the FiO₂ was decreased to 0.4, and the oxygen flow rate delivered via a non-rebreather mask was maintained at 15 L/
A pulse oxygen saturation of 90% was maintained during meals, while only under HFNC oxygen therapy. The HFNC was removed on Day 11 of hospitalization, and the oxygen flow rate delivered via a non-rebreather mask, was reduced to 10 L/min. Meanwhile, chest radiography showed no improvement (Figure 2C). On Day 12 of hospitalization, 6 L/min of oxygen was delivered via a nasal prong instead of a non-rebreather mask. On Day 17 of hospitalization, oxygen therapy was only administered as necessary. Oxygen therapy was discontinued on Day 13 of hospitalization, and the patient was discharged on hospital Day 26; the PCR result for SARS-CoV-2 was positive (Table 1). Two months after discharge, the patient returned to the outpatient department for a follow-up appointment where the patient reported improved performance of daily living activities, and improved chest radiography was observed (Figure 2).

### Discussion

In 2011, an outbreak of lung disease (HDALI) caused by inhalation of HDs was declared in Korea [7]. During the period of release (1998-2011), several companies manufactured HDs that could be mixed with water to eliminate microorganisms inside humidifier machines. Individuals exposed to vapor from HDs containing polyhexamethylene guanidine phosphate developed lung injury [8]. In severe cases individuals who developed lung fibrosis, died or underwent lung transplantation [9].

COVID-19 is a respiratory disease that was initially identified in Wuhan, China, in December 2019. It has a wide spectrum of symptoms, from an asymptomatic course or mild flu-like symptoms to respiratory distress [10,11]. One study reported that the severity of COVID-19 increases with age [12]. Patients > 65 years had a higher risk of admission to an ICU and had a higher risk of mortality [odds ratio (OR): 3.15 (1.40-7.09), \( p = 0.007 \)]. When analyzing severity of COVID-19 by age, patients 41-60 years showed an OR of 1.90 (0.69-5.25), while those > 60 years showed an OR of 4.04 (1.32-12.36) compared with patients 1-20 years. Thus, the results showed that as age increased, the disease severity also increased [12].

The Centers for Disease Control and Prevention have suggested that patients with certain risk factors are more prone to developing severe COVID-19. These include cancer, chronic kidney disease, chronic liver disease, CLD, dementia, diabetes mellitus, Down syndrome, heart conditions, human immunodeficiency virus infection, an immunocompromised state, mental health conditions, obesity, pregnancy, sickle cell disease, thalassemia, smoking, transplantation, cardiovascular...
disease, substance use disorders, and tuberculosis. In particular, they suggested that CLD included moderate to severe asthma, bronchiectasis, bronchopulmonary dysplasia, chronic obstructive pulmonary disease, and damaged or scarred lung tissue such as interstitial lung disease, cystic fibrosis, pulmonary embolism, and pulmonary hypertension [6].

Zheng et al reported that patients with a CLD, such as pulmonary fibrosis which is one of the main processes of HDALI, had a higher risk (OR: 5.15) of developing a critical condition [4]. However, studies on the CLD's role of progression are seldom reported [5].

In this current case, the patient was exposed to HDs, and pulmonary fibrosis progressed with dyspnea, which led to repeated hospital admissions. The most recent CT was performed 13 months prior to admission due to COVID-19 and showed a reduction in lesion size. Moreover, the patient showed improvements in the performance of daily living activities, and improvements were observed upon radiological examination. Hence, he was able to resume his business trip to Ukraine.

COVID-19 in patients exposed to toxic HDs are very rarely reported, so to generally apply the results of this single case to general cases should be taken with caution. Nonetheless, risk factors contribute to the progression of COVID-19 and may lead to critical disease. Despite the improvements in radiological findings and symptoms of CLD in this case such as HDALI with pulmonary fibrosis, determining CLD as a risk factor which may affect the clinical course of COVID-19 is important. Further studies about the impact of a medical history of lung disease on COVID-19 are needed to determine whether there is an association with critical progression of COVID-19.

**Author Contributions**

Study conception: YSH and HSS. Validation: YSH. Investigation: YSH. Manuscript writing: YSH and BSY. Manuscript review and editing: YSH and KY.

**Conflicts of Interest**

The authors have no potential conflicts of interest to disclose.

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**Ethical Statement**

Not applicable.

**Data Availability**

All relevant data are included in this manuscript.

**References**


