Case Report

Unusual paraseptal emphysema as the primary changes in computerized tomography scan of a COVID-19 patient

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Abstract

Covid-19 pandemic has infected more than 20 million people worldwide and claimed more than 750,000 lives so far. Given that this disease is new, the long-term lung effects for survivors especially of severe cases are unknown.

Most radiographic changes compared to those commonly seen in Acute Respiratory Distress Syndrome (ARDS), manifested as groundglass opacities or diffuse interstitial/alveolar changes.

We present a case of severe acute respiratory failure secondary to COVID-19 requiring prolonged mechanical ventilation and hospitalization with subsequent lung damage and unusual formation of extensive paraseptal emphysematous changes which predominantly affect the lungs apices with subsequent spontaneous pneumothorax.

Currently, the long-term impacts on survivors of severe COVID-19 infections are unknown. Future long-term follow-up studies will likely confirm a significant burden and many long-lasting disabilities to the society.

Keywords: COVID-19, VILI, Paraseptal Emphysema, Pulmonary fibrosis, Pneumothorax

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Case

Patient is a 77 year-old male with a past medical history of hypertension, Type 2 diabetes mellitus and hyperlipidemia, with no known previous lung problems, who contracted the SARS-CoV-2 virus in March of 2020 while on an Australian cruise with his wife. His symptoms of recurrent fevers, cough and hypoxemia rapidly progressed over several days prior to admission. Patient was intubated and placed on mechanical ventilation immediately after presenting to our emergency medicine department and was subsequently admitted to the Intensive Care Unit. His hypoxemia was so severe that he required postural manipulation with prone position ventilation for the first four days of his hospital stay. He required mechanical ventilation for a total of 56 days. A tracheostomy tube was placed to facilitate liberation trials from the ventilator. Throughout his hospital course, his pulmonary mechanics were similar to that previously described elsewhere in the literature, [1] with normal compliance and persistent severe hypoxemia. During his hospital course, the patient was treated with hydroxychloroquine and azithromycin (standard of care at the time), multiple courses of antibiotics for superimposed infections, convalescent plasma transfusions and one dose of tocilizumab (IL-6 inhibitor).

A non contrast computerized tomography (CT scan) of the chest was obtained on hospital day 50. It demonstrated moderate emphysema with severe paraseptal bullous changes predominantly at the lung apices (Figure 1) and an area of consolidative pneumonia in the posterior segment of the right lower lobe with a 1.6 cm area of parenchymal necrosis (Figures 2). Patient was eventually liberated off mechanical ventilation. On hospital day 88, the patient was discharged from our medical center to an acute care rehabilitation facility. While at that rehabilitation facility, he developed respiratory distress and was found to have a left-sided pneumothorax. He was subsequently transferred to a nearby hospital where the patient was placed back on mechanical ventilation and a thoracostomy tube was emergently placed. Patient's pneumothorax resolved and the chest tube was removed. Patient had a recurrence of another pneumothorax on that same side a few weeks later, most likely as a consequence of the rupture of those paraseptal emphysematous alveoli. Once again, he required another thoracostomy tube placement, which was eventually removed after resolution of the pneumothorax.

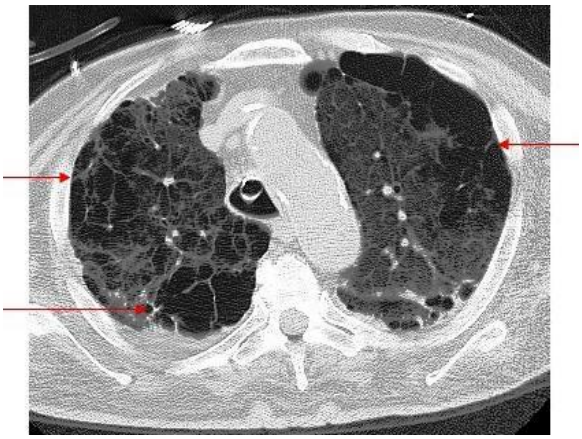

Figure 1: Axial non contrast CT of the chest showing extensive paraseptal (peripheral sub-pleural) emphysematous bullae of both upper lobes (red arrows)

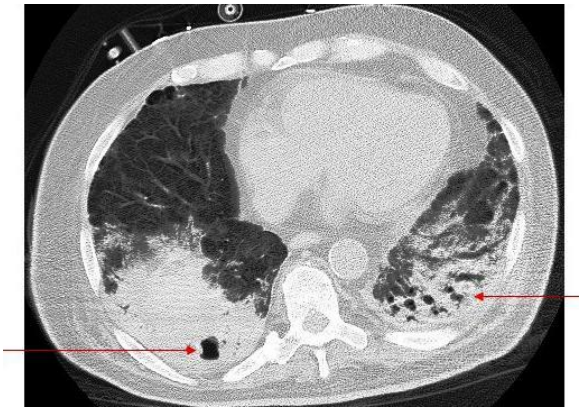

Figure 2: Axial non contrast Computerized Tomography of the chest showing extensive basal consolidations with foci of necrosis of both lower lobes (red arrows).

Discussion

Since first identified in Wuhan, China, in December of 2019, infection from SARS-CoV-2 has become a global pandemic. At this time, there has been more than 20 million cases and 750,000 deaths reported worldwide. [2] This virus is a member of the Coronaviridae family, a microbe that has caused significant devastation worldwide in cases of MERS and SARS. [3] The virus has predilection for the lungs and enters the cells via the Angiotensin Converting Enzyme-2 (ACE-2) receptors. [4] Pathological findings in diseased patients showed bilateral diffuse alveolar damage with cellular fibromyxoid exudates, desquamation of pneumocytes and hyaline membrane

formation similar to those found in acute respiratory distress syndrome (ARDS). Interstitial mononuclear inflammatory infiltrates, dominated by lymphocytes, were also seen similar to those found in cases of MERS and SARS. [5] Vascular malformations were also found, consisting of severe endothelial injury associated with the presence of intracellular virus and disrupted cell membranes, with widespread microangiopathy, microthrombi formation, and eventual global tissue ischemia. [6] Radiological findings, have demonstrated that about 10% of chest CTs were normal, while the most common abnormalities were ground glass opacities, with posterior and lower lobes predilection; other common manifestations were those of vascular thickening and diffuse infiltrates. Less common were pleural effusion, lymphadenopathy, airway secretions/tree-in-bud sign, pericardial effusion, and cavitation/cystic changes. [7] Another study by the same authors showed that Chest CT scans appeared to have a relatively high sensitivity in symptomatic patients at high risk of COVID-19, but specificity was poor and it cannot exclude COVID-19. [8]

As expected, not much is known as of yet about the long-term consequences and complications of COVID-19 survivors; this is particularly true in survivors of severe diseases and those who required invasive mechanical ventilation. As COVID-19 shares some pathological similarities to the familiar ARDS syndrome, and the previous MERS and SARS viruses, we can make some predictions.

Evidence suggested that survivors of severe ARDS may develop a fibro-proliferative response characterized by fibroblast accumulation and deposition of collagen and other extra-cellular matrix components in the lung, similar to lung fibrosis. [9] A 15 year old follow up study to survivors of SARS showed improvement in most patients' pulmonary functions tests and interstitial lung changes and fibrosis on CT scans, although still persisting in almost 5% of the cases. [10] Follow up of those affected by MERS is less documented; one follow up study of 36 patients [11] who recovered from MERS documented lung fibrosis on chest x-ray. A recent commentary cautioned about the long-term pulmonary consequences of COVID-19 and the substantial major health burden. [12]

The etiology of lung fibrosis post ARDS, SARS and MERS is not totally well understood, but transforming growth factor-β (TGF-β) and ACE-2 receptor mediated lung fibrosis are thought to play a significant role. [13] The activation of the TGF-β/Smad pathway is critical to the development of lung fibrosis. [14] Another possible etiology is ventilator induced lung injury (VILI) [15] in those who have been placed on mechanical ventilation. VILI can be manifested in many forms, not only due to the commonly known barotrauma, but also that of volutrauma, atelectrauma, biotrauma, and ergotrauma; postulated to be a consequence of lung stress and strain (lung stretch and repeated collapse along energy dissipation across tissues) during mechanical ventilation. [16] Diagnosis of VILI remains mostly clinical in practice and is difficult to distinguish from other forms of lung injury, such as that of nosocomial pneumonias or transfusion related lung injury (TRALI). Multiple biomarkers have been studied to determine the diagnosis, but so far, they all have been confined in the research arena. [17]

Although there have been very few reports of primary spontaneous pneumothorax [18] and secondary spontaneous pneumothorax due to emphysema, [19] our case is of particular interest in that our patient had no previous history of pulmonary disease and developed the severe paraseptal emphysema as a complication of his severe pneumonia and prolonged mechanical ventilation due to the COVID-19 infection.

An extensive literature search by us did not reveal any case report or case series reporting of para-septal emphysematous changes as a consequence of this COVID-19 disease. Significant and consequential sequelae may be that of persistent and irreversible hypoxemia, recurrent spontaneous pneumothoraces and broncho-pleural fistulae. This can result in prolonged hospitalizations, prolonged duration thoracostomy tube insertion, high risk surgical intervention, and associated long term co-morbidity state and even that of permanent disability.

We should keep in mind that the radiographic and structural changes in our patients' lung pathology is most likely a direct consequence of the COVID-19 lung infection; on the other hand, it could also be due to the related nosocomial infections, drug reaction, or VILI. Similar findings of these bullae formation have been documented on follow up studies of ARDS patients. [20] In addition, a similar case was published during the Influenza pandemic (H1N1) in which cystic emphysematous changes were attributed to VILI secondary to Airway Pressure Release Ventilation mode. [21]

In conclusion, COVID-19 lung injury is one of the most common manifestations of this disease state. Paraseptal emphysematous changes are quite rare and are not normally associated with this viral infection. This case point to the important association between paraseptal emphysema and COVID-19 pneumonia, as well as its potential devastating consequences, including that of persistent hypoxemia, recurrent pneumothoraces and possible broncho-pleural fistula. Large scale observational studies are encouraged to further define this crucial association.

References

1. Komorowski M, Aberegg SK. Using applied lung physiology to understand COVID-19 patterns. Br J Anaesth 2020 [published online ahead of print, 2020 May 26].

2. Johns Hopkins Coronavirus Resource Center. https://coronavirus.jhu.edu/. Accessed 2020 Aug 13.

3. Jun Zheng. SARS-CoV-2: an Emerging Coronavirus that causes a Global Threat. Int J Biol Sci 2020; 16(10):1678-1685.

4. Shang J, Ye G, Shi K, et al. Structural basis of receptor recognition by SARS-CoV-2. Nature 2020; 581:221–224.

5. Xu Z, Shi L, Wang Y, et al. Pathological findings of COVID-19 associated with acute respiratory distress syndrome. Lancet Respir Med 2020; 8:420–422.

6. Ackermann M, Verleden SE, Kuehnel M, et al.Pulmonary Vascular Endothelialitis, Thrombosis, and Angiogenesis in Covid-19. N Engl J Med 2020; 383:120-128.

7. Adams HJA, Kwee TC, Yakar D, et al. Chest CT Imaging Signature of COVID-19 Infection. In Pursuit of the Scientific Evidence. Chest 2020 [published online ahead of print, 2020 Jun 25]

8. Adams HJA, Kwee TC, Yakar D, et al. Systematic Review and Meta-Analysis on the Value of Chest CT in the Diagnosis of Coronavirus Disease (COVID-19). Am J Roentgenol. 2020;1-9.[published online ahead of print, 2020 Jun 1]

9. Burnham EL, Janssen WJ, Riches DW, et al. The fibroproliferative response in acute respiratory distress syndrome: mechanisms and clinical significance. Eur Respir J 2014; 43(1):276-285.

10. Zhang P, Li J, Liu H, et al. Long-term bone and lung consequences associated with hospital-acquired severe acute respiratory syndrome: a 15-year follow-up from a prospective cohort study. Bone Research 2020; 8:8.

11. Das KM, Lee EY, Singh R, et al. Follow-up chest radiographic findings in patients with MERS-CoV after recovery. Indian J Radiol Imaging 2017; 27: 342–349.

12. Spagnolo P, Balestro E, Aliberti S, et al. Pulmonary fibrosis secondary to COVID-19: a call to arms? Lancet Respir Med 2020; 8(8):750-752.

13. Delpino MV, Quarleri J. SARS-CoV-2 Pathogenesis: Imbalance in the Renin-Angiotensin System Favors Lung Fibrosis Front Cell Infect Microbiol 2020; 10:340-344.

14. Hu HH, Chen DQ, Want YN, et al. New insights into TGF-β/Smad signaling in tissue fibrosis. Chem Biol Interact 2018; 292(8):76-83.

15. Cabrera-Benitez NE, Laffey JG, Parotto M, et al. Mechanical Ventilation–associated Lung Fibrosis in Acute Respiratory Distress Syndrome A Significant Contributor to Poor Outcome. Anesthesiology 2014; 121(1):189–198.

16. Slutsky AS, Ranieri VM.Ventilator-induced lung injury. N Engl J Med 2013; 369(22):2126-2136.

17. Determann RM , Millo JL, Gibot S, et al Serial changes in soluble triggering receptor expressed on myeloid cells in the lung during development of ventilator-associated pneumonia. Intensive Care Med 2005; 31(11):1495-1500.

18. Ucpinar BA, Sahin C, Yanc U. Spontaneous pneumothorax and subcutaneous emphysema in COVID-19 patient: Case Report. J Infect Public Health 2020; 13(6):887-889.

19. Poggiali E, Vercelli A, Iannicelli T, et al. COVID-19, Chronic Obstructive Pulmonary Disease and Pneumomothorax: A frightening Triad. Eur J Case Rep Intern Med 2020; 7(7):001742.

20. Chiumello D, Coppola S, Froio S, et al. What's Next After ARDS: Long-Term Outcomes. Respir Care 2016; 61(5):689-699.

21. Sasidhar M, Chatburn RL. Tidal Volume Variability During Airway Pressure Release Ventilation: Case Summary and Theoretical Analysis. Respir Care 2012; 57(8):1325-1333.