Spontaneous Pneumothorax: A Complication of Coronavirus Disease 2019 (COVID-19) Patients

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Introduction

Some cases of pneumonia with unknown reasons were first found in Wuhan, China, in December 2019, which were later identified to be caused by SARS-COV-2 (severe acute respiratory syndrome coronavirus 2) and is currently named by the World Health Organization as coronavirus disease 2019 (COVID-19).1 Until now, the COVID-19 has developed into a global disaster and needs global attention.2,3 In the clinical work of prevention and control of COVID-19, we found by accident that some patients are prone to acquire spontaneous pneumothorax, especially the severe and critical ones, and that these patients might be associated with adverse outcomes. This study mainly discusses the causes of spontaneous pneumothorax in COVID-19 patients and the treatment measures for them, so as to found the relation between spontaneous pneumothorax and COVID-19 and to provide some clinical experience for saving the lives of these patients.

Method

In this study, the clinical information, past history, laboratory examination data, diagnosis, and treatment strategies of 21 COVID-19 patients with spontaneous pneumothorax, which occurred during hospitalization in Tongji hospital from January to March of 2020, were analyzed retrospectively. During this period, 207 cases including 108 (52.2%) males and 99 (47.8%) females were treated in our institution. In this study, the COVID-19 were diagnosed through clinical symptoms, epidemiological history, chest computed tomography (CT), and viral nucleic acid detection. The spontaneous pneumothorax was confirmed by clinical physical examination and/
or imaging examination and mainly included chest radiograph and ultrasound at the bedside. All COVID-19 patients who suffered newly spontaneous pneumothorax during their treatment period regardless of whether they had a history of spontaneous pneumothorax or not were enrolled in the study. The Kircher method was used to calculate the compressed lung area of pneumothorax, and the detailed data are shown in Table 1. The detailed clinical information, diagnosis, treatment strategies, and outcomes of these patients are shown in Tables 1 and 2.

Results
Among the 21 patients included in the study, 18 (85.7%) were male and 3 (14.3%) were female, with an average age of 55.95 ± 13.54 years (Table 2). The proportion of patients over 60 years old accounted for 38.1% (Table 2). Seven (33.3%) patients had basic lung diseases, including three (14.3%) cases of chronic obstructive pulmonary disease, one (4.8%) with a history of pulmonary tuberculosis, one (4.8%) with bronchiectasis, one (4.8%) with previous pneumothorax, and one (4.8%) with lung cancer (Table 2). Of the 21 patients, 16 (76.2%) patients had a history of smoking (Table 2). Based on different degrees of hypoxia in patients, all patients received different forms of oxygen therapy, including 18 (85.7%) cases of ventilator-assisted respiration, 2 (9.5%) cases of bilevel positive airway pressure assisted respiration, and 1 (4.8%) case of mask oxygen inhalation (Table 2). The ventilator parameters of 18 patients with ventilator-assisted breathing are shown in Table 2: all patients were accepted FiO2 (fraction of inspiration O2), which were more than 70% and positive end-expiratory pressure of these patients were between 0 and 3 cm H2O. The time between admission and pneumothorax ranged from 4 to 14 days, with an average of 8.24 ± 3.40 days (Table 2).

All patients were diagnosed with pneumothorax through clinical physical examination, bedside X-ray, and bedside ultrasound, with 12 (57.1%) patients suffered unilateral pneumothorax and 9 (42.9%) patients suffered bilateral pneumothorax, and 13 of 21 (61.9%) patients combined with pleural effusion at the same time (Table 1). In all patients, bilateral pneumothorax occurred on one side first and on the other side later. Four (19%) pneumothorax patients were complicated with mediastinal emphysema in the meantime, of which three were bilateral pneumothorax patients (Table 1). No subcutaneous emphysema was found in those patients. After definite diagnosis, all patients underwent unilateral or bilateral closed thoracic drainage to treat pneumothorax and pleural effusion, if any (Table 1). In patients who underwent closed thoracic drainage, the bubbles in the chest bottle were monitored every day and bedside ultrasound was used to monitor the lung recruitment. When there was no bubble in the chest bottle and the lung recruitment was good, the chest tube was clamped for 24 hours. If there was no bubble recurrence by bedside ultrasound within 24 hours, the closed thoracic drainage tube could be removed. The specific extraction time in our study was shown in Table 1. We considered that the best time to remove pleural effusion tube in patients with pleural effusion was when the pleural effusion was less than 50 mL. The patients with pleural effusion in our study were all removed the tube within 3 days. According to the patient’s dynamic condition, 6 (28.6%) cases accepted extracorporeal membrane oxygenation (ECMO) to support their lives (Table 1). The duration of chest tube placement was 3 to 10 days (mean: 5.29 ± 3.23 days) (Table 1). Finally, 9 (42.9%) patients died and 12 (57.1%) patients recovered smoothly (Table 1). Among the nine death cases, 5 died of kidney failure, 3 died of respiratory failure, and 1 died of septicemia (Table 1). In three COVID-19 patients with pneumothorax who died of respiratory failure, some tiny bubbles could be found in their lungs by CT scans on admission. Despite the positive measures were taken, the outcomes of these patients were still poor.

Discussion
As of March 11, 2020, 80,962 COVID-19 patients in China have been diagnosed and 3,162 have died, with the mortality rate being 3.9%. In our study, the mortality rate of COVID-19 patients combined with spontaneous pneumothorax is as high as 42.9%. Therefore, we suspect that spontaneous pneumothorax might be a sign of poor prognosis of COVID-19 patients, and we should pay high attention to these patients.

There is air between visceral pleura and parietal pleura, and the lungs contract continuously from the chest wall, which is called pneumothorax. From the clinical observation of the recent lung specimens obtained by autopsy of COVID-19 patients, a large amount of thick secretions can be seen on their lung surface, and the fibrous cord secretions secreted by infection were retained in the small airway, which damaged the ventilation and gas exchange function of lungs and blocked the small airway. As a consequence, the volume of dead cavity ventilation was increased and the pulmonary surfactant was decreased along with the decreased lung surface elasticity, which eventually can lead to the rupture of alveoli. Hyaline membrane was formed in the alveoli at the same time, which further hindered the exchange of oxygen and carbon dioxide between gas and blood. As the disease progresses, pulmonary fibrosis and consolidation may occur in these patients. These pathological changes suggest that the virus invades the lungs, impairs the lung function, and reduces the elasticity of the lungs after pulmonary fibrosis, which make pneumothorax more likely to occur. Positive airway pressure ventilation and other factors could further aggravate the pneumothorax. Similarly, in our study, some COVID-19 patients are more likely to develop pneumothorax, which may be related to decreased elasticity after pulmonary fibrosis and ventilator-related rupture of pulmonary bullae. In other words, the occurrence of pneumothorax is a complication and a sign of pulmonary dysfunction of COVID-19 patients.

In the current clinical work of three-level protection, auscultation cannot be effectively achieved; therefore, finding spontaneous pneumothorax in time has become a big problem. In our study, spontaneous pneumothorax was found in all patients by accident. Therefore, we suspected that spontaneous pneumothorax was a complication in COVID-19 patients.
**Table 1** The diagnosis, treatment strategies and outcomes of COVID-19 patients combined with spontaneous pneumothorax

<table>
<thead>
<tr>
<th>Number</th>
<th>The side of pneumothorax</th>
<th>Whether there is mediastinal emphysema or not</th>
<th>Whether there is subcutaneous emphysema or not</th>
<th>Whether there is pleural effusion or not</th>
<th>Compressed lung area</th>
<th>Is there stronger respiratory support used</th>
<th>Treatment method of pneumothorax</th>
<th>Drainage time for pneumothorax</th>
<th>Does pneumothorax recur after extubation</th>
<th>Outcomes</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>50%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>7</td>
<td>No</td>
<td>Died</td>
<td>Kidney failure</td>
</tr>
<tr>
<td>2</td>
<td>Left</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>40%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>5</td>
<td>No</td>
<td>Died</td>
<td>Kidney failure</td>
</tr>
<tr>
<td>3</td>
<td>Left</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>30%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>3</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Right</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>40%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>5</td>
<td>No</td>
<td>Died</td>
<td>Kidney failure</td>
</tr>
<tr>
<td>5</td>
<td>Right</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>35%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>3</td>
<td>No</td>
<td>Died</td>
<td>Kidney failure</td>
</tr>
<tr>
<td>6</td>
<td>Left</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>70%</td>
<td>ECMO</td>
<td>Closed thoracic drainage</td>
<td>/</td>
<td>No</td>
<td>Died</td>
<td>Respiratory failure</td>
</tr>
<tr>
<td>7</td>
<td>Right</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>30%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>3</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Right</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>30%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>3</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Right</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>35%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>3</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Right</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>50%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>5</td>
<td>No</td>
<td>Died</td>
<td>Kidney failure</td>
</tr>
<tr>
<td>11</td>
<td>Left</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>30%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>3</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Both sides</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>65%</td>
<td>ECMO</td>
<td>Closed thoracic drainage</td>
<td>/</td>
<td>No</td>
<td>Died</td>
<td>Respiratory failure</td>
</tr>
<tr>
<td>13</td>
<td>Both sides</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Left: 50%; right: 30%</td>
<td>ECMO</td>
<td>Closed thoracic drainage</td>
<td>10</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Both sides</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Left: 50%; right: 80%</td>
<td>ECMO</td>
<td>Closed thoracic drainage</td>
<td>10</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Both sides</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Left: 30%; right: 35%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>5</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Both sides</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Left: 80%; right: 65%</td>
<td>ECMO</td>
<td>Closed thoracic drainage</td>
<td>/</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Both sides</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Left: 30%; right: 30%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>9</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Both sides</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Left: 50%; right: 30%</td>
<td>/</td>
<td>7</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Both sides</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Left: 30%; right: 65%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>7</td>
<td>No</td>
<td>Died</td>
<td>Septicemia</td>
</tr>
<tr>
<td>20</td>
<td>Left</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>50%</td>
<td>/</td>
<td>Closed thoracic drainage</td>
<td>5</td>
<td>No</td>
<td>Recovery /</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Both sides</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Left: 30%; right: 65%</td>
<td>ECMO</td>
<td>Closed thoracic drainage</td>
<td>/</td>
<td>No</td>
<td>Died</td>
<td>Respiratory failure</td>
</tr>
</tbody>
</table>

*Abbreviations: COVID-19, coronavirus disease 2019; ECMO, extracorporeal membrane oxygenation.*
Table 2 The clinical information of COVID-19 patients combined with spontaneous pneumothorax

<table>
<thead>
<tr>
<th>Number</th>
<th>Sex</th>
<th>Age (years)</th>
<th>History of lung disease</th>
<th>Smoking History</th>
<th>Arterial PaO2 before oxygen therapy</th>
<th>Oxygen therapy before pneumothorax</th>
<th>Parameters of ventilator before pneumothorax</th>
<th>Time between admission and pneumothorax (days)</th>
</tr>
</thead>
</table>
| 1      | Male| 72          | /                        | Yes            | 53                                | Ventilator  
FiO2: 90%; PEEP: 3 cm H2O       |                                            | 4                                           |
| 2      | Male| 67          | PTB                      | Yes            | 55                                | Ventilator  
FiO2: 80%; PEEP: 3 cm H2O       |                                            | 4                                           |
| 3      | Male| 62          | /                        | Yes            | 56                                | Ventilator  
FiO2: 70%; PEEP: 2 cm H2O       |                                            | 8                                           |
| 4      | Male| 83          | COPD                     | Yes            | 52                                | Ventilator  
FiO2: 80%; PEEP: 3 cm H2O       |                                            | 3                                           |
| 5      | Male| 49          | /                        | No             | 55                                | Ventilator  
FiO2: 70%; PEEP: 0 cm H2O       |                                            | 12                                          |
| 6      | Female| 53      | /                        | No             | 51                                | Ventilator  
FiO2: 90%; PEEP: 2 cm H2O       |                                            | 16                                          |
| 7      | Male| 39          | /                        | Yes            | 56                                | Ventilator  
FiO2: 80%; PEEP: 0 cm H2O       |                                            | 6                                           |
| 8      | Male| 40          | Bronchiectasis           | No             | 61                                | BiPAP  
/                                |                                            | 8                                           |
| 9      | Male| 58          | /                        | Yes            | 53                                | Ventilator  
FiO2: 80%; PEEP: 3 cm H2O       |                                            | 8                                           |
| 10     | Male| 74          | /                        | Yes            | 55                                | Ventilator  
FiO2: 90%; PEEP: 3 cm H2O       |                                            | 14                                          |
| 11     | Male| 37          | /                        | Yes            | 57                                | Ventilator  
FiO2: 80%; PEEP: 0 cm H2O       |                                            | 11                                          |
| 12     | Male| 52          | /                        | Yes            | 53                                | Ventilator  
FiO2: 90%; PEEP: 2 cm H2O       |                                            | 10                                          |
| 13     | Male| 44          | /                        | Yes            | 52                                | Ventilator  
FiO2: 90%; PEEP: 3 cm H2O       |                                            | 9                                           |
| 14     | Male| 44          | /                        | Yes            | 52                                | Ventilator  
FiO2: 90%; PEEP: 2 cm H2O       |                                            | 12                                          |
| 15     | Male| 43          | Pneumothorax             | Yes            | 65                                | Mask inhalation  
/                |                                            | 6                                           |
| 16     | Male| 42          | /                        | Yes            | 51                                | Ventilator  
FiO2: 90%; PEEP: 3 cm H2O       |                                            | 8                                           |
| 17     | Male| 57          | /                        | Yes            | 62                                | BiPAP  
/                                |                                            | 5                                           |
| 18     | Female| 54     | /                        | No             | 54                                | Ventilator  
FiO2: 80%; PEEP: 2 cm H2O       |                                            | 7                                           |
| 19     | Male| 62          | COPD                     | Yes            | 53                                | Ventilator  
FiO2: 80%; PEEP: 3 cm H2O       |                                            | 6                                           |
| 20     | Female| 67     | Lung cancer              | No             | 55                                | Ventilator  
FiO2: 80%; PEEP: 0 cm H2O       |                                            | 10                                          |
| 21     | Male| 76          | COPD                     | Yes            | 51                                | Ventilator  
FiO2: 90%; PEEP: 2 cm H2O       |                                            | 6                                           |

Abbreviations: BiPAP, bilevel positive airway pressure; COPD, chronic obstructive pulmonary diseases; COVID-19, coronavirus disease 2019; FiO2, fraction of inspiration oxygen; PaO2, partial pressure of oxygen; PEEP, positive end-expiratory pressure; PTB, pulmonary tuberculosis.
pneumothorax might be easily neglected in many COVID-19 patients especially those with mild symptoms. Three cases of pneumothorax were found in the autopsy of nine COVID-19 patients, but they were diagnosed before death, indicating that the incidence of pneumothorax may be higher. Therefore, in our clinical work, we should pay close attention to the dynamic changes in patients’ condition, find out the causes immediately, and take appropriate treatments as soon as possible to prevent the further deterioration of the condition.

In our clinical work, if the COVID-19 patients have sudden dyspnea accompanied by the decrease of blood oxygen saturation and the blood pressure, the increase of heart rate, and the decrease of unilateral and/or bilateral thoracic motion amplitude, the occurrence of pneumothorax should be highly suspected. At this time, we should take timely physical examination, bedside chest radiograph, and bedside ultrasound to make clear diagnosis. Bedside ultrasound may be more timely than bedside X-ray for severe patients due to its convenience as well as immediate availability of results, especially for patients with ventilator-assisted respiration after tracheal intubation. Clear diagnosis in time creates a good opportunity for early treatment of the patients. For the treatment of this kind of patients, the first thing is to perform thoracentesis or closed thoracic drainage timely according to the compressed area of the lungs. For severe or critical patients, especially those whose respiratory function were assisted by ventilator and those with pleural effusion, closed thoracic drainage should be the primary choice because it can avoid repeated thoracentesis of the incompleteness of air extraction and the pneumothorax recurrence and, in the meanwhile, it also can deal with the complication of pleural effusion if any. Conservative treatment can be used for a small amount of mediastinal emphysma, and all patients finally absorbed it by themselves. For the patients with unilateral pneumothorax, we also need to focus on the other side of the lung to prevent the missed diagnosis of contralateral pneumothorax or to discover the newly contralateral pneumothorax without delay. For patients with serious lung diseases, we need to strengthen the treatments of primary lung diseases simultaneously. For patients whose breathing function is not improved after active treatments, stronger respiratory support strategies may be needed, such as ECMO. During the treatment period of the patients, if their arterial blood oxygen index is improved, the ventilator parameters should be reduced slowly until the ventilator can be stopped. All patients in our study were cured after closed thoracic drainage, and there is no recurrence of pneumothorax during their hospitalization. For patients who are prone to the recurrence of pneumothorax or patients with giant pulmonary bullae, surgical treatment should be performed after the patients’ condition is stable.

**Conclusion**

Active prevention and treatments of complications is an important part of the treatments of COVID-19 patients. The occurrence of newly spontaneous pneumothorax might be a sign of disease deterioration of the COVID-19 patients. Therefore, for COVID-19 patients, especially in severe and critical cases, it is necessary to detect pneumothorax early and take active measures early in the meantime to prevent the patients from poor prognosis.

**Conflict of Interest**

None declared.

**References**

1. Marty AM, Jones MK. The novel coronavirus (SARS-CoV-2) is a one health issue. One Health 2020;9:100123
3. Mahase E. Covid-19: UK records first death, as world’s cases exceed 100 000. BMJ 2020;368:m943