# **Pneumomediastinum and Pneumothorax in COVID-19 Patients**

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## **By**

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In May 2020, the SIET (Italian Society of Thoracic Endoscopy) organized a virtual roundtable of experts directly involved with the first phase of the SARS-CoV-2 pandemic. The aim was to share the experience acquired in the management of this disease in COVID-19 patients with severe clinical conditions requiring ventilatory assistance and endotracheal intubation. One of the main damages observed on these patients has been the high number of laryngo-tracheo-bronchial injuries, in addition to barotrauma lesions. This seems to be particularly related to the increasingly fragile tissues, especially in patients with specific comorbidities such as COPD, vascular diseases, diabetes, etc. This webinar was a great opportunity to discuss many aspects of this disease that are still unclear, and provide a perfect platform to share experiences, to improve the management of these kinds of patients with more appropriate indications, and then prove a correct diagnosis. Finally, the webinar has given the authors the chance to comment on the current status based on clinical experience through discussion of specific clinical cases.

The terrible spread of the SARS-CoV-2 (COVID-19) pandemic in the last few months has been characterized by the high incidence of interstitial pneumonia. The disease is associated with an acute condition with severe hypoxemia and bilateral pulmonary infiltrates and around 5% of patients with COVID-19 may have clinical conditions that require hospitalization in intensive care with the need for ventilatory assistance and endotracheal intubation. The clinical experience and preliminary data reported in the literature often suggest a minor efficacy of noninvasive ventilation for correcting the hypoxemic defect, and the early intubation and protective mechanical ventilation remain the cornerstones of treatment, that is not yet defined at all. Moreover, the damage to the lung is persistent, requiring prolonged care ventilation and the special setting of ventilation such as prone position ventilation. The specific respiratory dynamic, the high rate and duration of tracheal intubation have favored the inevitable risk of upper airways injuries, in particular, lesions mechanically induced to the trachea and the laryngotracheal tree, in addition to lung injury related to barotrauma with the onset of pneumothorax and pneumomediastinum. The high rate of infectivity of disease, the difficulties encountered in the availability and management of personal protection equipment to reduce the risks of contagion, the difficulty encountered in the reorganization of the local health systems starting from the A & E department, the diagnostic imaging unit, and the use of inadequately trained staff has further exacerbated the risk of these injuries. The diagnosis and correct management of iatrogenic lesions have also suffered due to the shortcomings typical of an emergency. Among the main clinical pictures related to iatrogenic injury, one has to remember injuries from barotrauma with lesions of small and medium-sized airways (pneumomediastinum, pneumopericardium) and pulmonary parenchyma (pneumothorax, pneumatoceles). In these cases, the correct clinical approach has a paramount meaning and should take into account also the security of the health workers.

On behalf of the Endoscopic Thoracic Italian Society (SIET), professor Franca Melfi, promoted and realized in June 2020 a WEB expert panel to describe the pathogenesis of barotrauma lung lesion, to illustrate the prevention mechanisms, to provide indications about the correct diagnosis, treatment and new devices and finally to comment on the current status based on clinical experience through discussion of clinical cases. Professor Filosso from the department of Surgical Sciences Unit of Thoracic Surgery University of Turin, Italy, and Dr Alan D. L. Sihoe, Honorary Consultant in Cardio-Thoracic Surgery, Gleneagles Hong Kong Hospital, have reported their experiences and debated around the theme of pneumothorax and pneumomediastinum in COVID-19 patients. The experience of professor Filosso reflects what happened during the first time of pandemic in Europe. Italy was one of the most affected European countries; Piedmont (where Torino is located), Lombardy, Veneto, and Emilia Romagna were the Italian regions where the viral spread was more intense in early 2020. The impact on the Italian health system was dramatic: there was a sudden reduction in beds availability (especially in intensive care-ICU) due to the exponential increase in infections and the demand for patients’ hospitalization. Some hospitals have been converted into “COVID hospitals,” while new ICU beds have been created in larger ones (especially in the most densely populated cities) by converting many operating rooms and wards previously dedicated to other types of care. Another critical key point was represented by the massive overload of patients in the emergency departments, which caused the need to redesign hospital infrastructures and dedicated pathways for potentially (or confirmed) COVID-19-positive patients. These conditions had therefore an enormous impact on medical/surgical hospital activities. Among the team of experts, professor Filosso discussed pneumomediastinum in COVID-19 patients, defined as an extraluminal gas entry into the mediastinum. It can be spontaneous, or secondary to barotrauma, or due to tracheal, broncho-tracheal, or esophageal injury. In the largest part of cases, the pathogenesis of pneumomediastinum follows the so-called “Macklin effect” [1].

It recognizes three pathological steps:

1. blunt traumatic alveolar ruptures represent the first moment
2. air dissects along bronchovascular sheaths and therefore
3. blunt emphysema spreads into the mediastinum.

During the COVID-19 pandemic, high-risk patients for pneumomediastinum development were those in whom mechanical ventilation with high-positive pressure was used, with the aim to manage severe respiratory failure caused by the bilateral diffuse lung involvement. The use of increased airway pressure (cPAP) also demonstrated to be one cause for pneumomediastinum development. In COVID-19 patients, pneumomediastinum was often associated with:

1. pneumothorax (usually bilateral)
2. subcutaneous emphysema
3. pneumatocele.

The treatment of COVID-19 pneumomediastinum was generally conservative (in the majority of cases). Some authors advocated for chest tube placement, especially when pneumomediastinum was associated with pneumothorax, or in cases of ventilated patients. In recent literature, cases treated with bilateral chest drainage placement along with a subcutaneous catheter have been described [2]. Currently, the authors believe that the key messages in COVID-19 pneumomediastinum are:

1. recognize and treat the possible tracheal injury
2. rule out possible esophageal causes.

The lack of a physical examination may put patients at high risk of being inappropriately treated, therefore, especially in ICU, a careful monitor of such patients is mandatory.

Dr Alan D. L. Sihoe reported his double clinical experience about the first SARS pandemic spread in 2003 in Hong Kong and the new experience with the new SARS-CoV- 2 pandemic, comparing the two experiences. In particular, in 2003, Hong Kong was the global epicenter of the Severe Acute Respiratory Syndrome (SARS) epidemic – caused by a coronavirus transmitted via the respiratory tract. Hong Kong accounted for 22% of all the confirmed cases worldwide, and sadly 37% of all the deaths [3]. At the two Hong Kong hospitals that treated the most SARS patients (n= 356), six (1.7%) developed spontaneous pneumothorax directly due to SARS [4]. In four patients, the pneumothorax was adequately managed by chest drainage alone. In two of these four patients, ventilatory support was required, which contributed to a prolonged air leak. However, in all four patients with chest drainage, no surgery was required and the one death was not due to the pneumothorax per se. The other two patients refused to receive chest drainage: one died from the SARS pneumonitis itself rather than the pneumothorax per se; the other recovered from both SARS and the pneumothorax. This experience from 2003 suggested that spontaneous pneumothorax can be caused by SARS, but can usually be managed relatively conservatively.

In 2020, the world was stricken by another coronavirus, causing the COVID-19 pandemic [5]. In many ways, COVID-19 was similar to SARS in terms of clinical presentation and transmission. This includes the observation that spontaneous pneumothorax can occur in patients with COVID-19 [6-12]. At the mid-June 2020, at least seven cases from around the world have been reported in the literature, including both men and women with ages ranging from 24 to 82 years [6-12]. In four of these patients, management included a chest drain insertion [9-12]. In none of the seven patients was surgery required. The experience was overall very similar to that seen with SARS. However, with a far greater total number of patients with COVID-19 worldwide in 2020, it is expected that more cases of spontaneous pneumothorax in COVID-19 patients will be reported in the near future, which may shed more light on its presentation and management. Besides spontaneous pneumothorax, pneumothorax secondary to barotrauma has also been reported with both SARS and COVID-19. For patients with SARS who required mechanical ventilator support in 2003, it was estimated that around 2% would develop barotrauma-related pneumothorax [13]. This figure of 2% was also reported in the initial experience with COVID-19 in 2020 [14]. It is noted, however, that at least two COVID-19 patients with barotrauma-induced pneumothorax were reported to have received surgery to manage prolonged air leakage [15]. In both reported cases, the surgery was performed thoracoscopically at the bedside in ICU and successfully stopped the air leak. Again, the number of reports on barotrauma-induced pneumothorax in COVID-19 patients is expected to grow in the coming months, hopefully shedding more light on its presentation and management. In the meantime, the World Health Organization advises that if higher positive end expiratory pressure (PEEP) is required for COVID-19 patients with more severe pneumonitis, ‘harmful effects’ should be monitored [16]. Regardless of whether the pneumothorax is spontaneous or secondary to barotrauma, chest drainage may be required.

As COVID-19 is believed to be transmitted through aerosols or droplets originating in the respiratory tract, it has been hypothesized that such aerosols and droplets may also be carried out of the patient via the chest drain when there is an ongoing air leak, potentially infecting other patients and hospital staff [17]. Even though no concrete proof that such transmission via the chest drain has occurred, this concern has already prompted several clinical societies to issue guidelines or statements regarding their use in COVID-19 patients [18-20]. The Asian Society for Cardio-Vascular and Thoracic Surgery has recommended that during the COVID-19 pandemic, any patient after surgery should not be discharged home with a chest drain in situ to avoid potential silent spread to the community [18]. The American Association for the Surgery of Trauma has recommended specific measures for the safe use of conventional water seal chest drain systems:

(i) adding bleach to the water seal chamber

(ii) applying an in line viral filter between the chest drain system and the wall suction or suction generator if suction is used

(iii) applying a bag-based viral filter to the suction port (or site or air exit from the system) if suction is not used, and

(iv) using cable ties to secure all connections in the chest tube and drainage system [19].

The British Thoracic Society recommends that in a patient with suspected or confirmed COVID-19 with a chest drain and air leak:

(i) connecting any chest drain to wall suction to create a closed circuit (reducing potential release or aerosols and droplets to the bedside environment);

(ii) applying a viral filter to the suction port of the drain system; and

(iii) use of a digital chest drain system (for example Thopaz) to reduce the risk of droplet spread [20].

The issue of a filter as mentioned in the above recommendations deserves a closer look. A coronavirus typically has a diameter of around 125 nm [16]. A ‘viral filter’ is designed to specifically offer filtration of particles down to just tens of nanometers [16, 19]. A bacterial filter – such as that used in the Thopaz digital chest drain system (Medela AG, Baar, Switzerland) – is technically not intended for filtration of viruses. However, a recent study found that coronavirus shedding in exhaled breath could be effectively prevented using normal surgical masks – which are also not viral filters [21]. An unpublished laboratory test has also demonstrated that the filter used in the Thopaz+ system was capable of effective filtration at a retention rate of 97.43 to 99.27% for aerosol suspension with 27 nm particles – which are substantially smaller than coronaviruses [22]. The above British Thoracic Society recommendation of using a digital chest drain system is therefore interesting and worthy of validating in future clinical studies.

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