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Case Report

Pneumomediastinum due to spontaneous tracheal breach in COVID-19☆

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ABSTRACT

Patients who have contracted coronavirus disease 2019 (COVID-19) have a wide variety of complications, many of them involving the respiratory system. One noted complication has been pneumomediastinum. The 63-year-old gentleman, in this case, had contracted COVID-19 and was admitted to the hospital for hypoxemia. He required high-flow nasal canula oxygen but did not get intubated. On day 12 of admission, the patient had a rapid hypoxemic episode after rising from a chair and fell. Diffuse airspace infiltrates were seen on chest x-ray, signifying a possible pneumomediastinum. A CT scan confirmed pneumomediastinum, and the likely mechanism was a tracheal breach just superior to the carina. This case highlights a unique mechanism as few papers have described this etiology with such clear imaging. Surgical treatment options were considered since the likely etiology could be traced to the tracheal defect, but the patient was ultimately managed conservatively with high flow nasal cannula oxygen.

Introduction

Pneumomediastinum, also known as mediastinal emphysema, is usually seen after an iatrogenic injury during intubation or due to trauma [1,2]. Spontaneous pneumomediastinum was seen in 11.6% of patients with SARS-CoV during the SARS outbreak of 2004 [2]. Since the beginning of the COVID-19 pandemic, spontaneous pneumomediastinum has been a documented complication [1]. Although vaccines were available to all adults at the time of this case, this patient was unvaccinated. The delta variant was predominant in the Southeast of the United States, and the disease course was poor for unvaccinated individuals at the time of this case. Therefore, a high index of suspicion for poor disease progression and the varied complications and sequelae of COVID-19 is required as these patients can present with unusual pathologies.

Case

A 63-year-old gentleman was admitted to the hospital for COVID-19 pneumonia. Prior to arrival, the emergency medical technicians stated his oxygen saturation was 80% on room

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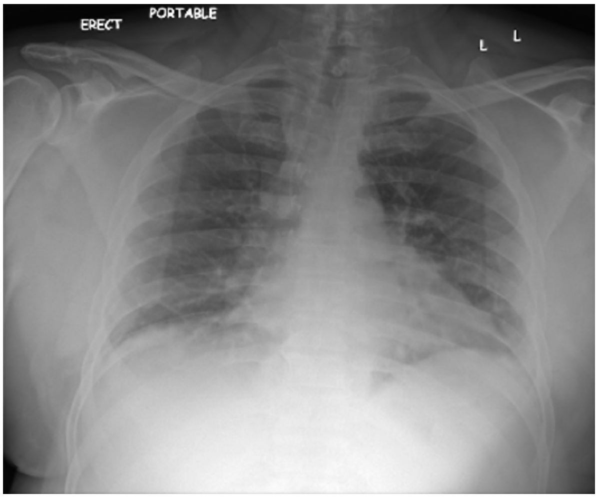

Fig. 1 – Chest X-ray at admission revealing multifocal bilateral pulmonary patchy opacities consistent with multifocal pneumonia. No pneumomediastinum or pneumothorax was noted.

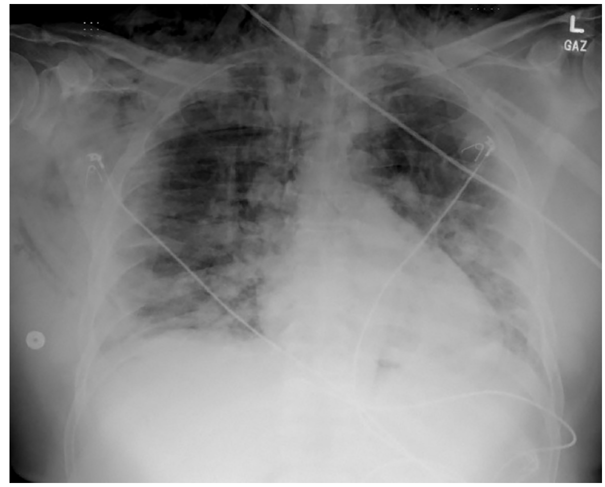

Fig. 2 – Chest X-ray after desaturation noting a likely pneumomediastinum and bilateral diffuse airspace disease.

Fig. 3 – Axial CT image with an arrow highlighting tracheal breach. Peripheral consolidative and ground-glass opacities in lung fields.

air and improved with 2 liters of oxygen via nasal cannula. His chest x-ray at admission showed multifocal bilateral pulmonary patchy opacities consistent with multifocal pneumonia (Fig. 1). Past medical history included diabetes mellitus type 2 and hypertension, for which he took multiple medications. He had no history of smoking. Dexamethasone, apixaban, and remdesivir were initiated per the COVID-19 protocol at the time. He remained on oxygen via a high-flow nasal cannula during the next week of hospitalization and had dyspnea at rest and on exertion. On hospital day 12, the patient fell in the hallway after removing the high-flow nasal cannula and rising from a chair. His oxygen saturation was in the sixties at that time.

Subcutaneous emphysema in the left neck was seen on physical exam. Due to concern for bleeding, a CT scan of his head was performed but showed no focal abnormalities. However, a chest X-ray revealed possible pneumomediastinum with subcutaneous emphysema and diffuse airspace disease bilaterally (Fig. 2). Later that day, a CT scan of his chest documented pneumomediastinum and subcutaneous emphysema with a tracheal breach of approximately 4 mm (Figs. 3 and 4). The CT scan was performed with oral contrast allowing the radiologist to note the absence of esophageal rupture. The patient remained stable with 100% oxygen via high-flow nasal cannula and was closely monitored with serial chest x-rays. A third chest x-ray was taken three days after the initial pneumomediastinum showing improved mediastinal air and subcutaneous emphysema, so the concentration of oxygen (FiO2) began to be weaned. Yet over the next week, 2 more instances of severe hypoxemia with O2 saturation in the sixty and seventies occurred. The patient recovered quickly from these episodes with oxygen via a high-flow nasal cannula or non-rebreather mask. Although he remained in the hospital and required continual titration of oxygen, he eventually improved and was discharged from the COVID-19 unit to in-hospital rehab with severe fatigue and dyspnea on exertion, which was presumed to be caused by deconditioning from his lengthy hospital stay. The patient's fatigue and dyspnea eventually improved, and he was discharged home.

Discussion

Pneumomediastinum has been a documented complication of COVID-19 since January 2020 in Wuhan, China [3]. Pneumomediastinum is commonly caused by iatrogenic damage or trauma but can also be related to air space diseases such as asthma, bronchiectasis, or chronic obstructive pulmonary disease [4]. In the cases of pneumomediastinum secondary to COVID-19, the hypothesis has been that there is a loss of alveolar membrane integrity due to diffuse alveolar damage [1]. This mechanism, known as the Macklin effect, states that alveolar rupture due to direct alveolar injury

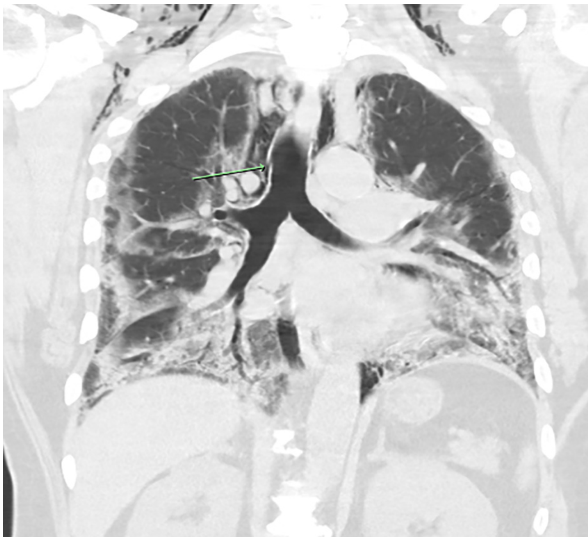

Fig. 4 – Coronal CT image with an arrow highlighting tracheal breach. Peripheral consolidative and ground-glass opacities in lung fields most prominent in the bilateral lower lobes.

causes air to leak, dissect the bronchovascular sheaths, and diffuse into the mediastinum [5,6]. Once this occurs, the air tracks into the subcutaneous tissues leading to subcutaneous emphysema in about 70% of cases [7]. The Macklin effect has been used to explain the cause of pneumomediastinum in COVID-19 patients in nearly all cases written [1,5,8–10]. This is because COVID-19 damages the type 2 pneumocytes creating inflammation and damage to the alveoli [1,9]. As a result, the alveoli become more susceptible to rupture and, therefore, allow a pneumomediastinum to occur [1,10,11].

In this case, a unique etiology is the probable explanation for our patient's pneumomediastinum. As seen in Figs 3 and 4, it is likely due to a tracheal breach. This is unusual as there was no attempted intubation. Spontaneous tracheal breach has been recognized only a few other times [2,12]. It is thought that the increase in intrathoracic pressure from coughing and falling in a trachea already inflamed from disease and weakened by steroids led to the breach [1,2,5,8,9]. In a study looking at the physiology of coughing, the pressure can be as high as 300 mm Hg during the compressive phase where the glottis is closed and expiratory effort begins [13]. This study also found that after the glottis opens, turbulent air flows out of the lungs at a rate as high as 12 L/s. This requires the trachea to withstand extreme changes in pressure and airflow. To accommodate this, the trachea is a hollow, cartilaginous structure. The thickness of the tracheal ring is 3 mm and there are C-shaped cartilage rings every 4 mm [14] to allow the trachea to maintain its shape. In a study investigating the tensile strength of tracheal cartilage, it was found that the tensile strength decreased as the samples became more distal [15]. This is notable since the tracheal breach seen in this case was just superior to the carina. In addition to the forceful coughing and fall, this patient had COVID-19 which is known to cause inflammation. The virus is known to enter cells through the angiotensin-converting enzyme-2 receptors located in many tissues, including the alveoli and trachea [1,16]. This leads to an inflammatory response causing endotheliitis, leading to edema and, therefore, a less stable tissue [17]. The endotheliitis combined with the increased pressure from coughing and falling likely led to the tracheal breach seen in the CT images [1,5,9] (Figs. 3 and 4).

In this case, the treatment of their pneumomediastinum was considered. In reviewing prior case reports, most patients recovered without surgical intervention [5,8–10]. In a 2020 literature review of fifteen cases of pneumomediastinum in patients with COVID-19, it was found that 11 patients recovered with conservative management, and 4 passed away [1]. The patient in this case was discharged home after being treated with conservative management; however, different options in the case of decompensation were considered. The most invasive option was a thoracotomy with primary repair. This is typically reserved for cases where the trachea injury is greater than 4 cm or if more conservative measures fail [18]. A tracheal repair can be complicated by tracheal stenosis from hyperplasia of granulation tissue leading to airway compromise [19]. In addition, it is imperative that the repair is tension-free since the physiology of respiration relies on pressure gradients [19]. The tracheal breach was approximately 4 mm in this patient's case, so a primary tracheal repair was a last-resort option [12]. Another option was stent placement under bronchoscopic guidance. This was documented in a case of an iatrogenic tracheal breach where a self-expanding metal stent was placed within the trachea allowing tracheal integrity to be maintained [20]. Finally, in the case of airway compromise or unstable vital signs, intubation either orally or with a tracheostomy could be performed. Although this is not a direct treatment for the breach, it has several benefits. First, it can give surgeons time before a primary repair can be done. Second, the endotracheal tube can be placed in such a manner to encourage healing by primary intention, and third, it can support the trachea in the case of collapse. Care should be taken when placing the tracheal tube due to the risk of extending the tracheal tear [19]. Placing the tube under bronchoscopic guidance is beneficial. A study comparing tracheostomy under bronchoscopic guidance at the bedside to open tracheostomy showed no increase in complications and proved to be cost saving [21]. It is also an improved technique for COVID-19 positive patients where limiting patient transport out of negative pressure environments should be considered.

Although this patient improved with conservative management, different treatment options, including surgical management, was considered in the event of decompensation. Understanding the pathophysiology and etiology of a patient's pneumomediastinum is important when choosing treatment options. The imaging in this case highlights the spontaneous tracheal breach proving to be an unusual mechanism to pneumomediastinum.

Consent and ethics

IRB waive

Due to the nature of this being a case report, this paper does not need IRB approval.

Patient consent

Informed consent has been obtained from the patient. Care was taken to de-identify the patient and radiographic images show no remarkable identifiers.

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