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ORIGINAL ARTICLE

Applying High-Frequency Oscillatory Ventilation (HFOV) Successfully in Idiopathic Pulmonary Fibrosis Patient, Potential Challenge

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ABSTRACT

Patients with Idiopathic pulmonary fibrosis (IPF) are known to frequently experience the life-threatening consequence of pneumothorax. Pneumothorax is a buildup of air around the lung but inside the pleural cavity. It happens when air gathers inside the chest between the visceral and parietal pleura. This idiopathic pulmonary fibrosis and pneumothorax lead to surgical emphysema. It occurs when gas or air seeps into the subcutaneous tissue (the skin's lowest layer). The main objective of this clinical case study is to determine how the patient's requirements and ABG change when one condition leads to another. A patient of 60 years with a medical history came to the emergency department with a chief complaint of shortness of breath and chest pain. On his arrival, the oxygen saturation was 68% at room air, and a chest X-ray revealed pneumothorax. He was then shifted to a pulmonary team to floor as surgical emphysema, secondary pneumothorax (right) on intercostal space chest tube, and CAP (community-acquired pneumonia). ABG tests were taken after every step of the lung-protective strategy: post-intubation, post-HFOV connection, after disconnection, after switching to PCMV, and post-HFOV disconnection. These results indicate the severity of the patient's condition. Even after the percutaneous tracheostomy procedure, the patient was still experiencing the challenges of increased oxygen requirements and recurrent spontaneous pneumothorax.

Keywords: Idiopathic pulmonary fibrosis (IPF), Pneumothorax, High frequency oscillatory ventilation (HFOV), acute respiratory distress syndrome (ARDS)

INTRODUCTION

Idiopathic pulmonary fibrosis is the most frequent type of pulmonary fibrosis. It is a disorder that causes fibrosis of the lungs (NIH, 2022). The term "idiopathic" refers to a condition with no known cause. Scarring stiffens the lung and makes breathing difficult. Lung damage from it is progressive and irreversible, which means it worsens with time. As the condition progresses, affected persons experience shortness of breath after moderate exercise or exertion. They may breathe quickly and shallowly (Richeldi et al., 2017). A dry, hacking, ineffective cough may also develop. Individuals who are affected may endure uncontrollable coughing fits. Certain drugs such as nintedanib and pirfenidone can help to slow it down in some circumstances. People with IPF may be suggested for lung transplantation occasionally (Hernandez et al., 2018). It can also lead to severe medical disorders including lung infection (pneumonia) and collapsed lungs (Pneumothorax). Primary spontaneous pneumothorax has no clinical indications or symptoms until a bleb rupture, the consequences of which are usually shortness of breath and acute chest pain, especially in secondary spontaneous pneumothorax. X-ray is frequently used to diagnose a pneumothorax. Moreover, Arterial blood gas tests measure the levels of hypercarbia, hypoxemia, and acidemia, the presence of which is determined by the degree of cardiopulmonary compromise(Daley, 2022). When a pneumothorax is detected, chest radiography provides extra information besides confirmation like severity, potential causes, a baseline from which to proceed, and help with the therapeutic approach (Sze-To et al., 2021). Many techniques such as ETT, PCMV, HFOV, and percutaneous tracheostomy are used for respiratory distress management. However, some strategies such as Intubation can lead to surgical emphysema. It can be widespread, rapidly spreading, disfiguring, and life-threatening at times, thus necessitating immediate interventions (Ghosh et al., 2018).

Case Presentation

Demographic data: A Saudi male of 60 years old

Patient Complaint: Shortness of breath and chest pain

A 60-year-old Saudi man with known hypertension was diagnosed with IPF in 2020, on the waiting list for lung transplantation, brought to the emergency department with a complaint of Sudden, extreme shortness of breath and sharp chest pain extending to the right side of his upper back.

Past Medical History: The patient denies any recent hospitalization, wheezing, upper respiratory infections, or fever. Additionally, there is no history of cancer, pulmonary embolism (PE), or deep vein thrombosis (DVT). No past traumas other than back muscular pain. He previously experienced flu-like symptoms two weeks ago, coughing up yellow phlegm.

Vaccination and Medications: He received two doses of the COVID vaccine, a COVID swab test result was negative, and he was taking Prednisolone, Amlodipine, Nintedanib, Vitamin D, and Calcium at home.

Initial Physical examination: The patient was extremely tachypneic upon arrival at the emergency room. Initial physical examination results indicate:

- Blood pressure (BP) 146/88
- Temperature 37°
- Respiratory rate (RR) 30
- Heart rate or Pulse rate 122
- Oxygen saturation is 68% at room air. After taking oxygen through a basic face mask, O2 saturation increased to 92 % on 6l/min, and respiratory distress reduced.

Initial evaluation: Chest x-ray: Chest x-ray (figure1) showed significant right-sided pneumothorax due to which chest tube was inserted.

Diagnosis: On December 31, 2021, the patient was brought under the pulmonology team's care. The potential diagnosis were

- Surgical emphysema
- Right secondary pneumothorax
- Community-acquired pneumonia.

Confirmatory evaluation: Oxygen saturation of the patient was 95 percent on Nasal cannula 3L. However, the patient was still tachypneic and breathing at a rate of 30 breaths per minute. The patient's condition deteriorated, and his O2 requirements increased to 15L through the non-rebreather mask. Oxygen

saturation was 88 percent showing the worsening chest X-ray (figure2). He was then shifted to ICU as he necessitates immediate escalation management.

Table 1:

Abbreviation	Definition
IPF	Idiopathic pulmonary fibrosis
CAP	Community-acquired pneumonia
ABG	Arterial blood gas
HFOV	High frequency oscillatory ventilation
PCMV	Pressure control mandatory ventilation
ETT	Endotracheal tube
PE	Pulmonary embolism
DVT	Deep vein thrombosis
BP	Blood pressure
RR	Respiratory Rate
PEEP	Positive end-expiratory pressure
FiO2	fraction of inspired oxygen
ARDS	Acute respiratory distress syndrome
MAP	Mean airway pressure
AMP	Amplitude
SSP	Secondary spontaneous pneumothorax
DLCO	Diffusing capacity for carbon monoxide
VILI	Ventilator-induced lung injury
mPAW	Mean Airway Pressure
UIP	Usual interstitial pneumonia
HRCT	High-resolution computed tomography

Figure 1: this chest X-ray illustrate large right-side pneumothorax,

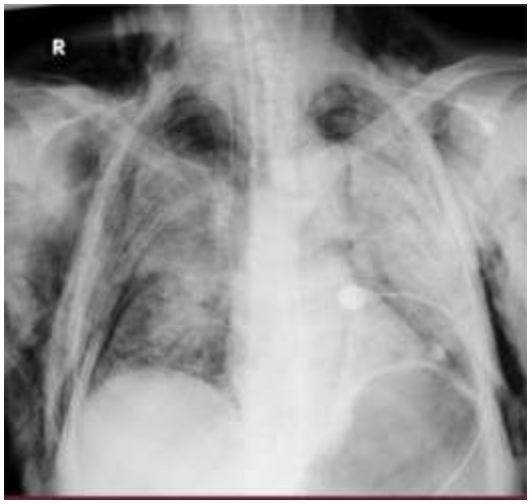

Figure 2: worsening of chest X-ray

BIPAP: It started on/off, followed by acute breathlessness and desaturation.

ABG:

pH	7.40
PCO2	45.8
PO2	47
HCO3	26.7

The patient was electively intubated based on his condition, previously mentioned. He was on ETT of size 8 and lip level 22cm, on PCMV mode, initial settings: Pressure Control(18), Respiratory Rate (RR) 28, Positive end-expiratory pressure (PEEP) 8, a fraction of inspired oxygen (FiO2) 100%. After that, the ARDS protocol was started, and the ETT cuff gets ruptured, so it was changed through a bougie.

Chest X-ray: (figure3) Showed an increase in surgical emphysema.

Figure 3: post intubation chest X-ray, there are intermittent areas of radiolucency which represent increase in surgical emphysema

Post intubation ABG results:

pH	7.02
PCO2	117
PO2	118
HCO3	18

HFOV: Based on the above ABG results, the doctor requested the start of HFOV due to type 2 respiratory failure and the patient's continued desaturation on 100 % FiO2. The HFOV was initiated with the following initial settings: MAP 22, AMP 90, Hz 4.5, and FiO2 100 %.

After HFOV connection, ABG results are:

pH	7.27
PCO2	53
PO2	87
HCO3	22

ABG was taken every four hours, and the settings were modified depending on each ABG reading. The DNR was signed, and the doctor gave the order to transition to standard mechanical ventilation.

ABG results before disconnection

pH	7.44
PCO2	48
PO2	93
HCO3	31

Patient then switched back to PCMV with a setting of PC-16, PEEP-14, RR-25 and FIO 80%.

ABG results after one hour

pH	7.09
PCO2	112
PO2	148
HCO3	24.8

The patient then again connected to HFOV with the initial setting of MAP 20, AMP 75, Hz 6, and FiO2 40. The patient weaned slowly from HFOV to conventional mechanical ventilation after 14 days, with the HFOV disconnection setting being MAP 20, HZ 6, AMP 75, and 40% FiO2.

ABG after Disconnection was

pH	7.14
PCO3	102
PO2	299
HCO3	26

The patient again switched to PCMV mode, initial setting: PC 18, PEEP 10, RR 34, and FiO2 100%.

ABG results after PCMV mode were:

pH	7.14
PCO3	104
PO2	249
HCO3	26.4

Settings were changed in accordance with each ABG's results until they were properly compensated.

ABG results were:

pH	7.38
PCO3	70
PO2	63
HCO3	35

Percutaneous tracheostomy: When the patient was hemodynamically and vitally stable, awake, and oriented, the size 8 percutaneous tracheostomy procedure was performed. Its goal was to shift the patient from mechanical ventilation to an aerosol or high flow trach mask, if tolerated, with weaning attempts made each day, according to the HRCT and chest radiograph (figure 4, 5), tracheostomy tube noted, Nasogastric tube noted. Right-sided chest tube noted. Lungs and plural: Secretions identified in the upper trachea. Patent airways. No pleural Effusion. Diffuse bilateral peripheral reticular opacities with honeycombing and traction bronchiectasis. No evidence of significant pneumothorax. There is a patchy air space opacity identified in the left lower lung lobe. Scattered bilateral Sub segmental atelectasis. Mediastinum and heart: No pericardial effusion. Multiple enlarged mediastinal lymph node, the largest measures 1.2 cm identified in the right lower paratracheal area. Thyroid appears Unremarkable. Bones and chest wall: No sclerotic or lytic lesion seen. No enlarged axillary lymph nodes. Limited evaluation of the upper abdominal cuts appears grossly unremarkable. To Conclude, the above findings are most likely related to UIP, left lower lung patchy of air space opacity which may be related to infectious/inflammatory Process. For clinical correlation No evidence of significant pneumothorax.

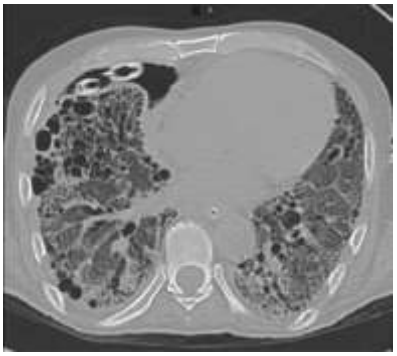

Figure 4. Chest radiograph findings: Tubes and lines as displayed. Decreased Lung volumes bilaterally, Reticular pattern involving predominantly lower lobes and subpleural surfaces.

The patient was still in the ICU because of difficulty weaning from the mechanical ventilator and increased oxygen requirements. He also experiences recurrent spontaneous pneumothorax. After it, the patient was transferred to another hospital.

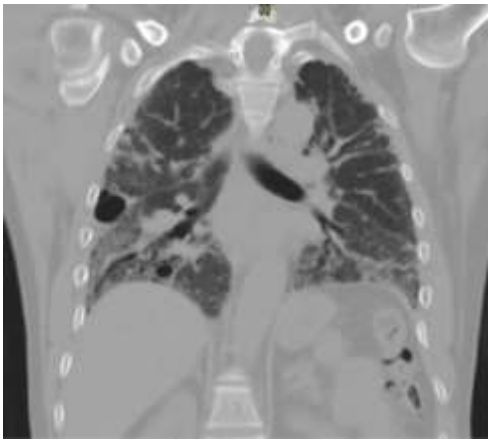

Figure 5: HRCR findings: A hallmark of honeycombing at lower lobes, subpleural location. traction bronchiectasis, and extensive ground-glass abnormality; consisting with usual interstitial pneumonia (UIP). Does not need to be confirmed by histology.

DISCUSSION

Patients with chronic lung conditions such as Idiopathic pulmonary fibrosis (IPF) are susceptible to pneumothorax. According to several reports, Primary spontaneous pneumothorax occurs in people without any chronic lung disease and is related to lower recurrence and mortality rates than in patients having pneumothorax with chronic lung disease (Stodghill et al., 2019). Pneumothorax in IPF patients is challenging to treat successfully and has higher recurrence rates and a generally poor prognosis (Yamazaki et al., 2021).

Patients with a recurring air leakage from the chest tube used for drainage are recommended to have surgery (MacDuff et al., 2010). However, due to poor pulmonary function, age, recurrent pneumothoraxes or other comorbidities, some individuals with secondary spontaneous pneumothorax (SSP) are not suitable candidates for surgical surgery (Bhimji, 2020). Additionally, IPF might become acutely exacerbated following surgery.

For patients with chronic air leaking from the chest tube, chemical pleurodesis may be a nonsurgical option. For successful chemical pleurodesis, the lung must completely re-expand. However, some patients having pneumothorax do not have lung re-expansion due to the distinct rigidity of lung parenchyma in IPF (Upagupta et al., 2018).

According to reports, hospital death rates for patients with SSP ranged from 4.5-17.9%. Surgical emphysema was the most prevalent underlying issue in these reports (Onuki et al., 2017). Moreover, despite considerable radiographic signs of pulmonary disease, the Combined Pulmonary Fibrosis and Emphysema syndrome's physiological effects include preservation of lung volumes and spirometry values as well as a marked gas exchange impairment that is shown as a drop in DLCO (Hage et al., 2021). The other complications of a patient having idiopathic pulmonary fibrosis with pneumothorax and surgical emphysema are pulmonary hypertension, lung cancer, and acute lung injury (McKnight et al. 2019).

HFOV is a rescue for a patient having air leak syndrome i.e., IPF, pneumothorax, and surgical emphysema. It is a powerful technique for increasing alveolar recruitment and can help to protect the lungs from damage (Meyers et al., 2019). In order to sustain alveolar recruitment and prevent VILI, the strategy makes use of volumes, less than dead space while maintaining a constant

mPaw. HFOV prevents the lung inflate-deflate cycle by maintaining the lung inflation at a constant, airway pressure (less variable) with sinusoidal flow oscillation and improves oxygenation. When using HFOV, oxygenation and CO2 removal take place as long as the lung remains inflated. After the start of HFOV therapy, alveolar recruitment persists for several hours, and PaCO2 readings may initially increase.

CONCLUSION

Pneumothorax (collapsed lung) is a major cause of morbidity in patients with IPF. It occurs due to the leakage of air into the space between the chest wall and the lung leads to low oxygen saturation, as indicated in the above scenario (68% O2 saturation in room air before any therapy). Clinical symptoms of pneumothorax are shortness of breath, sharp chest pain, fatigue, etc. ETT can be performed to alleviate the symptoms of pneumothorax, but it can also lead to surgical emphysema characterized by the entrapment of air within the subcutaneous tissues leading to increased partial pressures of CO2 (hypercapnia). HFOV therapy can be performed to eliminate the excessive CO2 and returns the arterial blood pressure to normal. Despite different strategies, there are greater chances of about 20-60% of spontaneous pneumothorax recurrence, which leads to extreme respiratory acidosis and acute respiratory failure. In that case, percutaneous Tracheostomy must be considered for the patient with respiratory failure who requires mechanical ventilation for more than seven days and is anticipated to make a significant recovery. It helps in reducing the sedative requirements and facilities the weaning of a patient from a ventilator.

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