ZEPHYR ENDOBRONCHIAL VALVE UNDER CHARTIS SYSTEM GUIDANCE AS A LIFESAVING INTERVENTION FOR PERSISTENT AIR LEAK – A CASE REPORT

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ABSTRACT:

A pneumothorax that progresses to ongoing air leaks can result in extended hospitalizations and significant morbidity. The overall incidence of persistent air leak (PAL) is unknown. The clinical significance of PAL includes prolonged use of chest tube which increases the risk of pneumonia, deep venous thrombosis, subcutaneous emphysaema and empyema, restricted ambulation due to chest tube leading to progressive deconditioning due to inactivity, prolonged requirements for pain medication, hospital acquired infections and economic strain on the patient. While surgical management is often the preferred option for addressing air leaks, it frequently involves high risks, as many patients have compromised baseline respiratory conditions and additional health issues. Over the last decade, new and less invasive techniques in interventional pulmonology have emerged. We describe a case of a patient with a persistent air leak following a pneumothorax who was effectively treated with the insertion of Zephyr endobronchial valves (EBV). Despite extensive drainage, negative pressure application, and two attempts at autologous blood patch pleurodesis, the air leak continued. Due to his comorbidities and poor lung condition, he was not an appropriate candidate for surgery. Two sequential sessions of Zephyr EBV were performed, successfully stopping the air leak. The patient was discharged shortly after, following a thorough clinical and radiological monitoring. This case highlights the effectiveness and safety of Zephyr EBV, providing a less invasive option compared to surgical procedures.

Keywords: Alveolar pleural fistula, bronchopleural fistula, persistent air leak, pneumothorax, endobronchial valves, pleurodesis, autologous blood patch, secondary pneumothorax

INTRODUCTION

Primary spontaneous pneumothorax (PSP) arises in individuals with previously healthy lungs. In contrast, secondary spontaneous pneumothorax is observed in those with pre-existing conditions such as chronic obstructive pulmonary disease (COPD), associated with trauma, patients on mechanical ventilation or in patients with infectious causes. Those with secondary pneumothorax tend to experience more symptoms, face greater treatment challenges, and are more likely to have recurrences since their lungs are already compromised. If there is communication via an alveolar pleural fistula (APF) or bronchopleural fistula (BPF), the pneumothorax will persist. A PAL is identified when the air leak lasts longer than 5-7 days, typically demonstrated by ongoing air bubbling and movement of the fluid column in the intercostal drain [1].

Less invasive bronchoscopic techniques can assist patients who are not ideal candidates for surgery. Zephyr EBV was originally developed for bronchoscopic lung volume reduction for emphysema. However, the potential for using Zephyr EBV to support the recovery of high-risk surgical patients through a safer and less invasive approach has been thoroughly researched [2].

CASE REPORT

We describe a case involving a 65-year-old gentleman who came to a district private hospital after experiencing worsening breathlessness over 1 week. He is a current smoker, consuming one pack daily. Additionally, he was recently diagnosed with type 2 diabetes mellitus, essential hypertension, and dyslipidaemia, and he was adhering to his prescribed medications. He is a retired technician. Upon his arrival, there was a suspicion of an acute exacerbation of COPD, prompting a chest X-ray. The chest radiograph revealed a complete pneumothorax on the right side. Computed Tomography (CT) scan of the chest confirmed the pneumothorax (Figure 1). He was admitted and a 20 French intercostal drainage tube (ICD) was inserted in the right pleural cavity on day 0. After 72 hours (day 3), the lung failed to expand on follow-up chest X-ray (Figure 2). Hence, he was referred to a tertiary private hospital. On admission, he was hemodynamically stable, with mild tachypnoea of 26 breaths per minute. He was treated with low-flow oxygen at 1-2 litres per minute, nebulized bronchodilators, prophylactic antibiotics, and chest physiotherapy. Given the PAL (Cerfolio grade 4), a trial of suction was attempted to abate the pneumothorax. However, it failed. The patient opted for non-invasive methods to address the PAL after a detailed discussion about multiple options. An 80 ml autologous blood patch was attempted on day 7 through the ICD. However, the pneumothorax persisted, and the lung failed to expand (Figure 3). A repeat CT scan of the chest demonstrated a ruptured right upper lobe bulla as a cause of the secondary spontaneous pneumothorax. A trial of continuous suction of 5-10 cmH2O, low-flow oxygen, chest physiotherapy, and mucolytic was given. The pneumothorax and air leak persisted.

A second autologous blood patch through the ICD, and use of a larger-bored ICD of 28F, on day 10, was tried due to worsening of the pneumothorax over baseline. The patient agreed to undergo intervention for persistent air leak using Zephyr EBV after day14. The patient underwent flexible bronchoscopy under general anesthesia, and the Chartis System was used to identify the site of the air leak [3]. It consists of a balloon catheter and a console that demonstrates the flow and pressure sensors. The catheter was inserted into the right lower lobe segments, and the balloon was inflated to completely occlude the test segment. Airflow was measured by the Chartis system, which displayed constant negative pressure, indicating that the air leak was coming from the right lower lobe. Chartis visually displayed rapid disappearance of initial 150 ml/minute expiratory air flow and at the same time a continuous negative pressure identifying both the target lobe and airway segment with persistent air leak increasing to -2 cm of H2O. (Figure 4). Due to the distorted anatomy, we were unable to place the balloon catheter properly in the right upper lobe to assess the air leak. In contrast, in the right middle lobe, a non-continuous cyclical negative pressure indicated a normal patient’s inspiratory pattern, indicating no air leak there. Hence, we decided to put the Zephyr EBV in the right lower lobe. Before deployment, the valve size was determined by using the marker on the delivery catheter tip, and the appropriately sized valve was loaded into the catheter and deployed into the right lower lobe segments. 4 Zephyr EBVs (EBV, Pulmonx Inc., Neuchatel, Switzerland) were deployed successfully in the RB6, RB7, RB8, and RB9 segments of the right lower lobe. The procedure was uneventful with good recovery. Post procedure, there was no improvement in dyspnea, and Cerfolio grade 3 of air leak persisted (Figure 5). A repeat CT chest confirmed total collapse of the right lower lobe, and a persistent pneumothorax (Figure 6A, 6B). On Day 17, the patient was allowed a trial of ambulation using a Sinapi XS chest drainage system. Follow-up X-ray showed worsening; hence, he was switched back to an underwater seal with a low-pressure suction system. He was slowly weaned off oxygen in the next 5 days, but with a persistent air leak, Cerfolio Grade 3.

Due to the persistent air leak after day 30, he underwent a second EBV deployment, suspecting an air leak in the right upper lobe clinically. EBV was deployed in the RB1, RB2, and RB3 after sizing (Figure 7). The bubbling immediately stopped post-deployment. 48 hours later, there was no radiological evidence of pneumothorax, with an expanded lung and collapsed right upper and lower lobes (Figure 8). He was discharged on ambulatory drainage and called back after 3 days clamping of the tube, and subsequently the tube was removed on day 35 since the initial presentation. He remained radiologically and clinically stable after 4weeks of discharge (Figure 9). Apart from the slight slough formation at the chest wound, his X-ray chest showed collapsed RUL, RLL, and minimal pleural thickening. At this moment, he is well with optimized inhaler therapy for his COPD and is planned for an elective removal of his EBV between 9-12 weeks after the initial insertion.

DISCUSSION

Pseudoaneurysms from PAL can be classified as per Cerfolio into 4 grades [1]. Grade 1 is where leak is appreciated only during forced expiration, especially on coughing. In Grade 2, leak is seen in expiration only, whereas in Grade 3, it is seen in the inspiratory phase only. Grade 4 patients have continuous bubbling during both phases of respiration. Such leaks tend to be large and difficult to manage. PAL is most often noted in patients with severe underlying lung disease, trauma, those on invasive mechanical ventilation, and in post-thoracic surgery patients.

Effective PAL management is largely based on many factors, like etiology, duration of the leak, grade of the leak, underlying lung status, surgical fitness, clinician's expertise, and patient's preference. A multidisciplinary management plan incorporating inputs from pulmonary specialists, interventionalists, and thoracic surgeons should be considered, as PAL is a complex issue. Current treatments of PAL include prolonged chest tube drainage with continuous wall suction, Heimlich valve, videothoracoscopy with parenchymal stapling and or mechanical pleurodesis and surgery [4]. Bronchoscopic options include glues, Watanabe spigots, gel foam, cellulose and EBV [5-6]. However, none have been approved for use in the US and around the world. Given that there are many bronchoscopic options to treat PAL and none have gained widespread acceptance, the success rate of every bronchoscopic method is difficult to determine. EBV has become a safer and effective management option for poor surgical candidates. In a prospective study done on 17 non-operative patients, the mean number of valves was approximately 3, mostly in the left upper lobe. The mean duration of hospital stay postoperatively was approximately 18 days. Successful intervention with EBV was defined as the ability to wean off suction, resolution of the air leak, and removal of the intercostal drain tube. A statistically significant reduction in the length of stay after implantation of EBV could be noted [2]. In contrast, our patient required 7 valves placed in 2 separate procedures in 2 lobes (upper and lower lobes) to stop the PAL and was in the hospital for 27 days. Studies show high success rates for EBV placement in managing PAL, ranging from 72.7% to over 91% [7-8].

In another study, 21 patients underwent 24 valve placement procedures, with a mean of 3 valves being placed. The underlying cause of persistent air leak was postoperative in 8, pneumothorax in 11, cavitary lung infection in 3 cases, and postpneumonectomy BPF in 2 patients. No valve-related complications or mortality were noted, and the median duration to chest tube removal after initial valve placement was 15 days [9]. Another large case study involving 40 patients with spontaneous, post-surgical, or iatrogenic and traumatic causes for PAL, 37 patients treated with Zephyr EBV had reasonable air leak cessation and good outcomes [10]. In another large multicentric Italian study they found early introduction of valves could improve patient outcomes especially in advanced cerfolio grades of air leaks. Similar to other studies, the valves were deployed after a median time of 19 days. Among the 59 patients who received valves, 40 had complete resolution within 24 hours after valve placement, and 19 patients within 7 days irrespective of cause of the air leaks [11].

11 cases of PALs following secondary spontaneous pneumothorax, or following a surgical intervention, were treated with EBV, among which 8 patients had a favourable outcome [12]. Another study involved 25 patients with PAL who underwent EBV. The results are similar in most of the studies, with very few serious adverse events associated with EBV, unlike those noted in the VENT trial [14]. Valve misplacement, migration, expectoration, mild hemoptysis, and infection are the commonly encountered complications [5]. Valve-related mortality was not identified in PAL cases managed with EBV.

In our case, we had given two trials of chest tubes with an underwater seal and autologous blood patch, which failed. The difficulty in assessing the air leak from the right upper lobe due to distorted anatomy made the case challenging to manage. The decision to place EBV in the right upper lobe in the second procedure was made based on a clinical judgement, as the Chartis system could not guide us. EBV under Chartis guidance was chosen over other bronchoscopic approaches (glues, Watanabe spigots etc) as it uses the Chartis system to help identify the site of air leak accurately (right lower lobe). Post-second EBV insertion, the chest tube could be removed within 6 days. The advantage of EBV is that it is a one-way valve that allows for expiration and clearance of bronchial secretion, thus decreasing the risk of post-obstructive pneumonia. It is recommended that the valves be removed after 6 weeks since the alveolar-pleural fistula would have healed by then. The optimal time for EBV removal should be based on clinical judgement and experience.

CONCLUSION

Zephyr EBV offers a minimally invasive and effective treatment option for persistent air leaks, providing a valuable alternative to surgical intervention. By selectively occluding the affected airway, EBV can help to reduce or eliminate air leaks, promote faster healing, and improve patient outcomes.

In patients with persistent air leaks who have failed conservative management or are poor surgical candidates, EBV has great potential in reducing mortality, morbidity, and healthcare costs. Selecting the best course of management for patients with PAL warrants an individualized therapeutic approach, close monitoring, and multidisciplinary collaboration between interventional pulmonologists and surgeons.

CONFLICTS OF INTEREST

The authors have no potential conflicts of interest to disclose and are in agreement with the contents of the manuscript.

DATA AVAILABILITY STATEMENT

The data presented in this report is available from the corresponding author upon reasonable request.

INFORMED CONSENT STATEMENT

Informed consent was obtained from the patient for both procedure and publication and ensured regarding non-disclosure of identifiers, respecting confidentiality and patient privacy.

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FIGURE LEGEND:

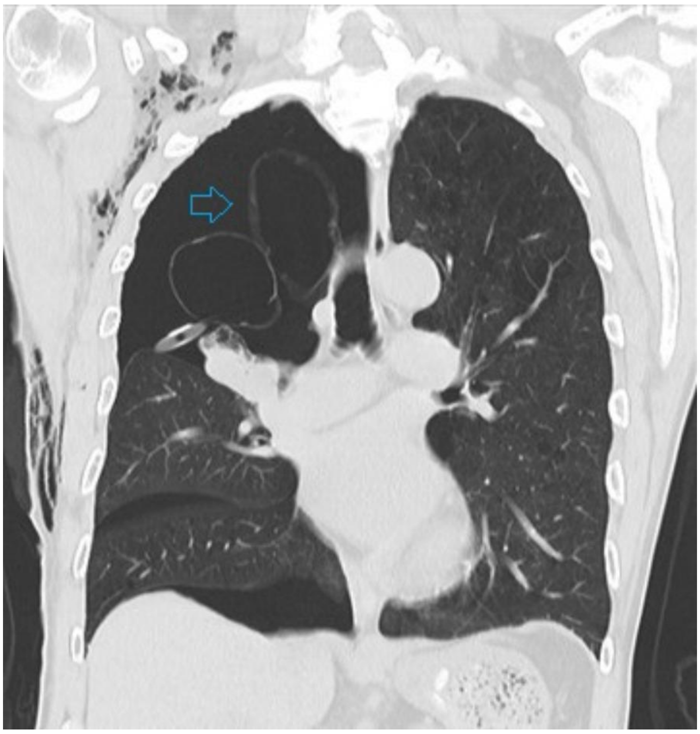

Figure 1 : CT image showing a large pneumothorax with underlying bullae on the right side (Arrow) with emphysematous changes on the left side

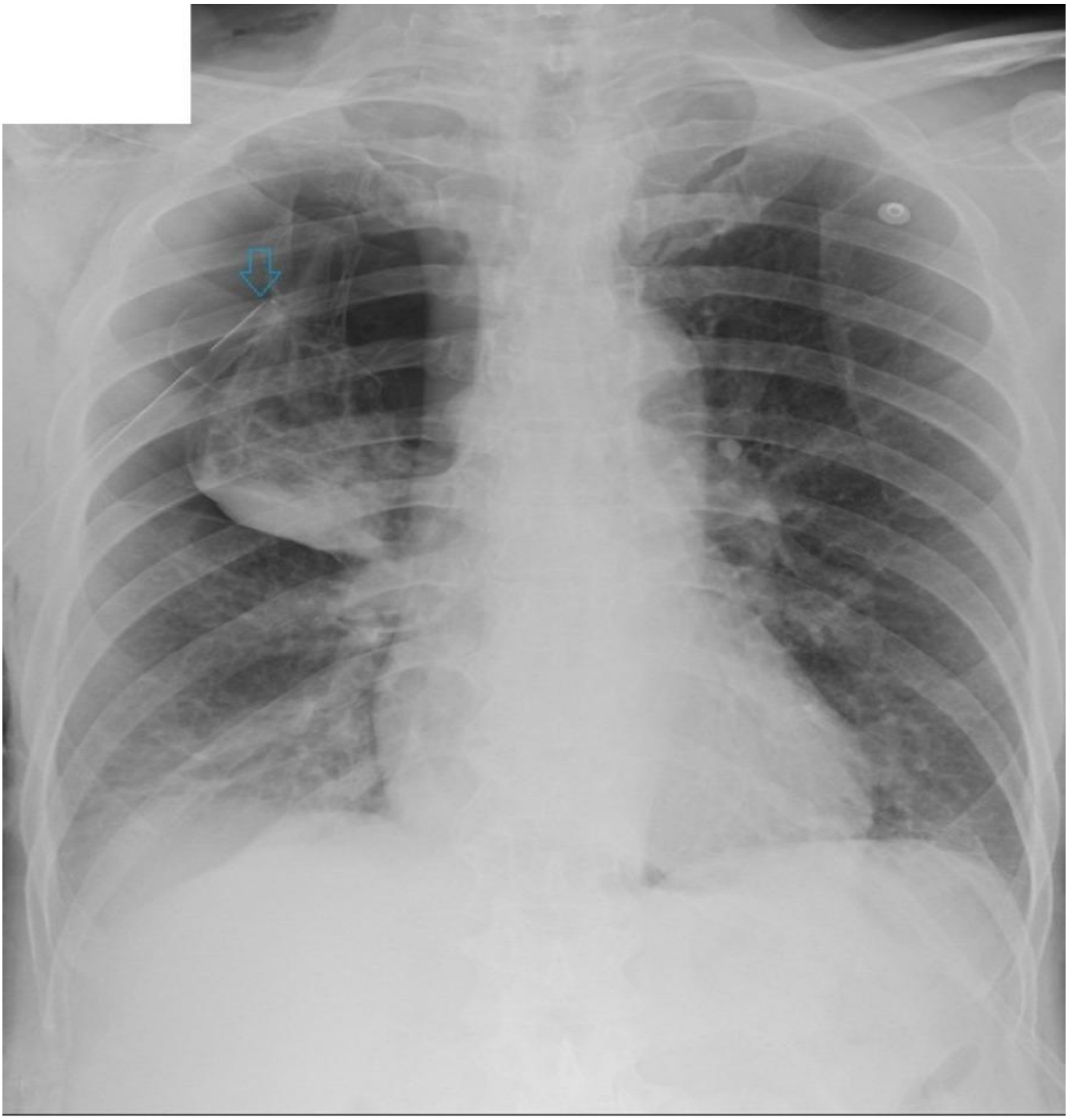

Figure 2: Figure 2 – Chest radiograph showing partial expansion with intercostal drain in situ (Arrow)

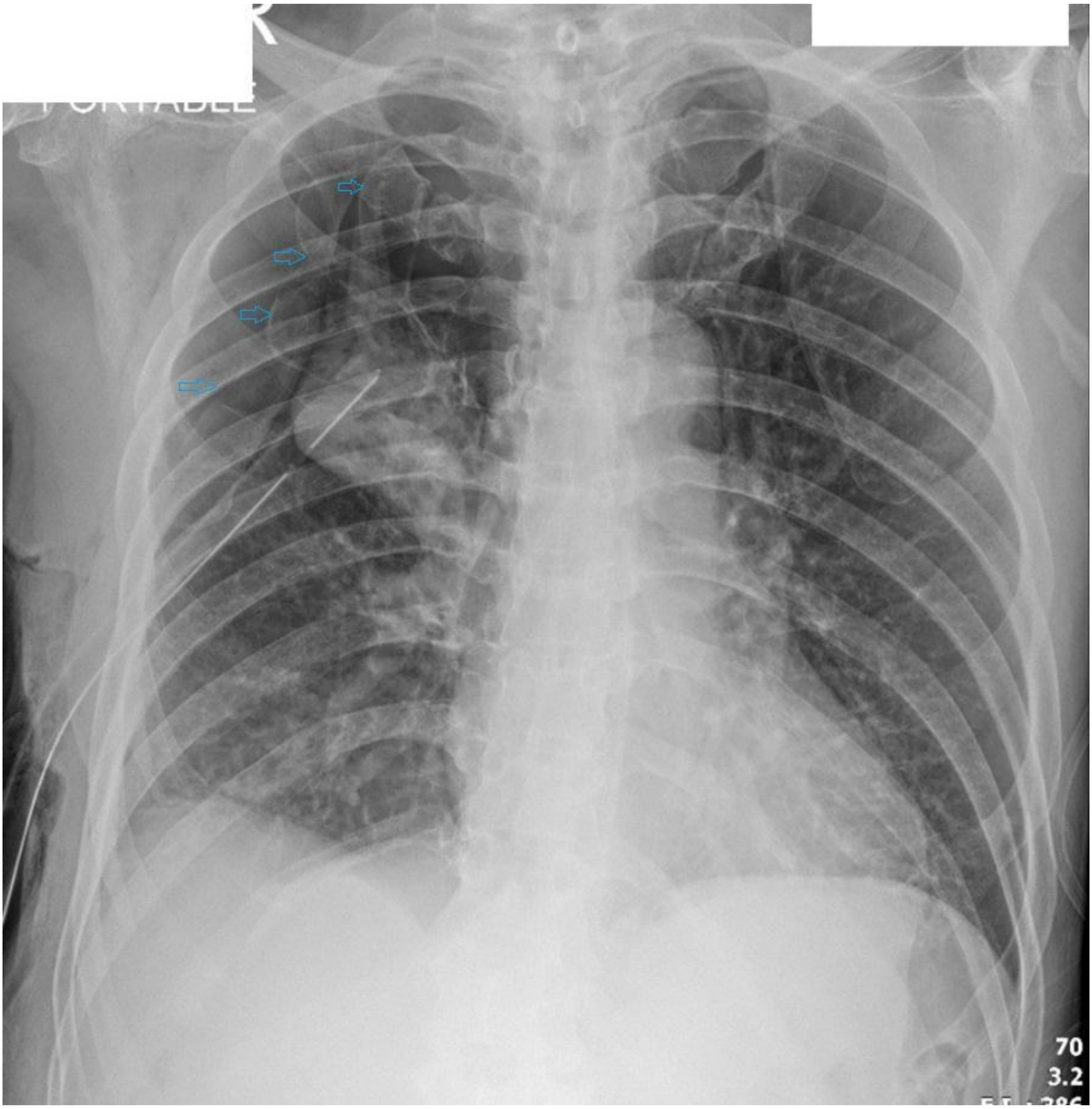

Figure 3 – Chest radiograph showing persistent pneumothorax after autologous blood patch

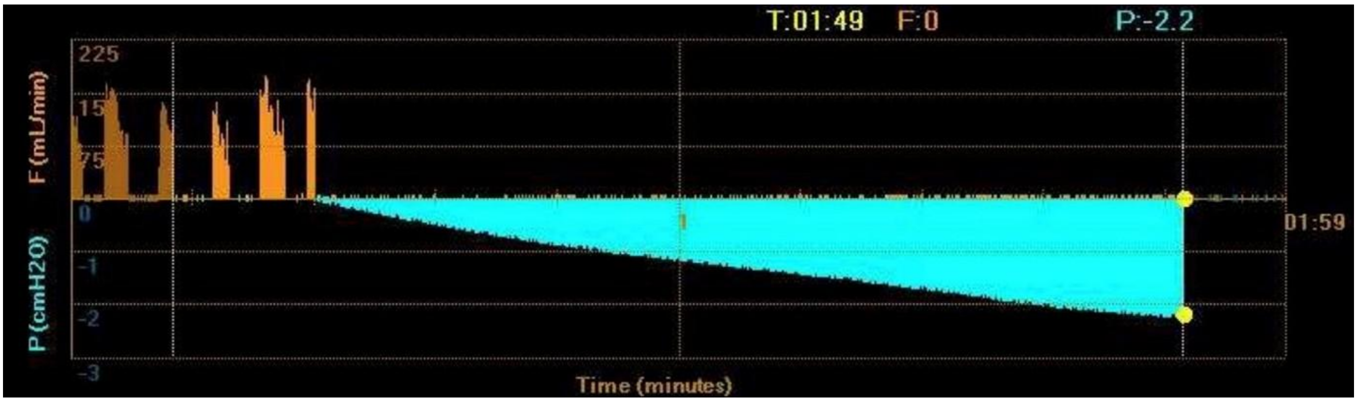

Figure 4 – Occlusion of the right lower lobe showed the disappearance of airflow and constant negative pressure displayed by the Chartis system, indicating the leak was from the right lower lobe.

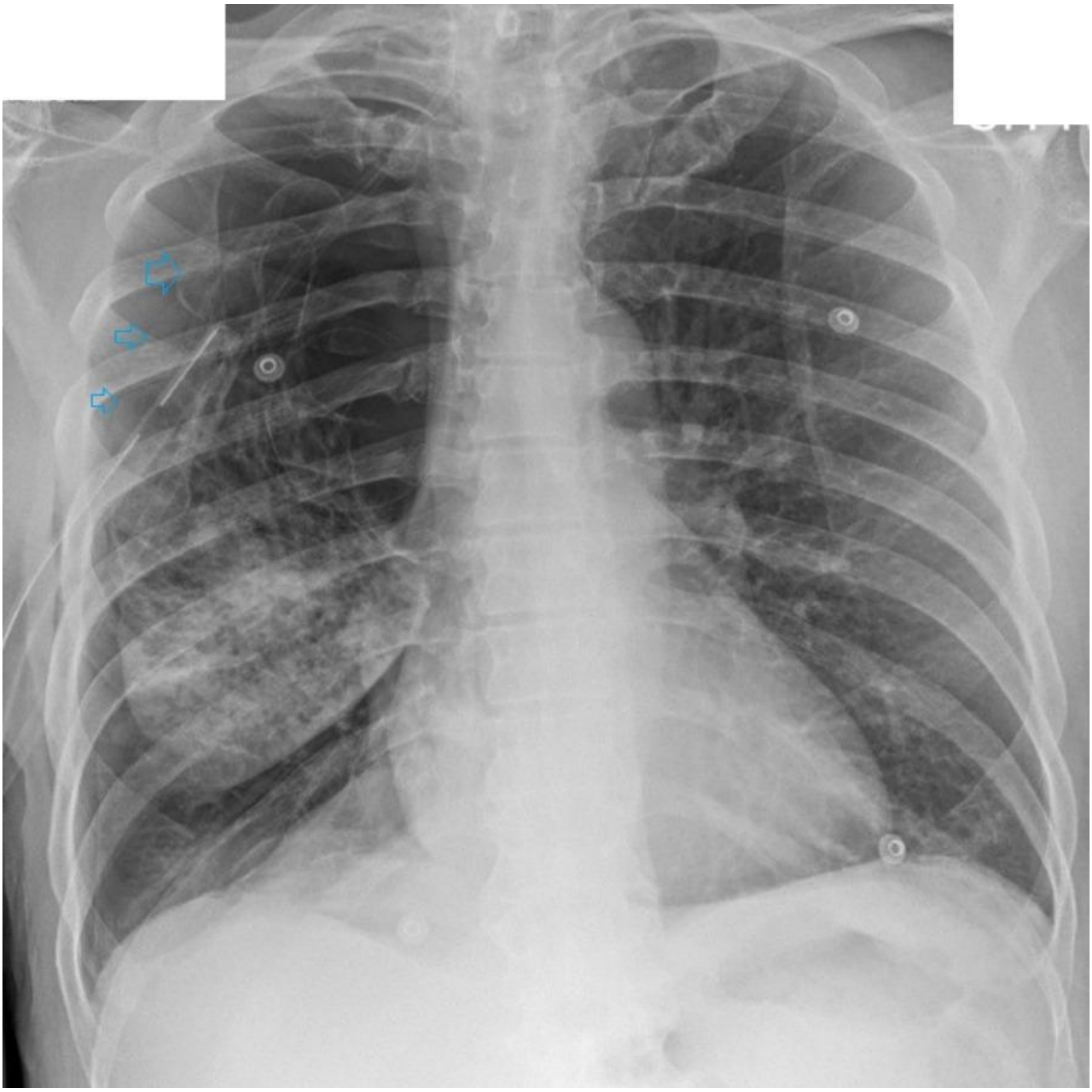

Figure 5: Post first EBV insertion into the right lower lobe. Pneumothorax is persistent on the right side.

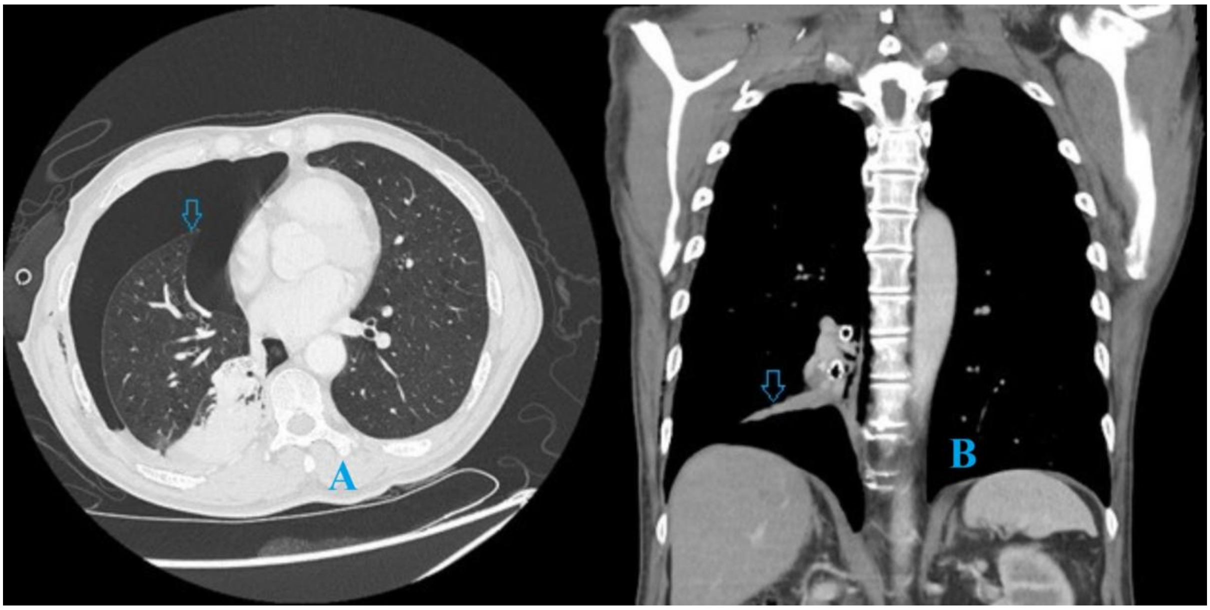

Figure 6(A & B): CT images post first EBV insertion into the right lower lobe demonstrated persistent air leak and collapsed right lung (Arrow).

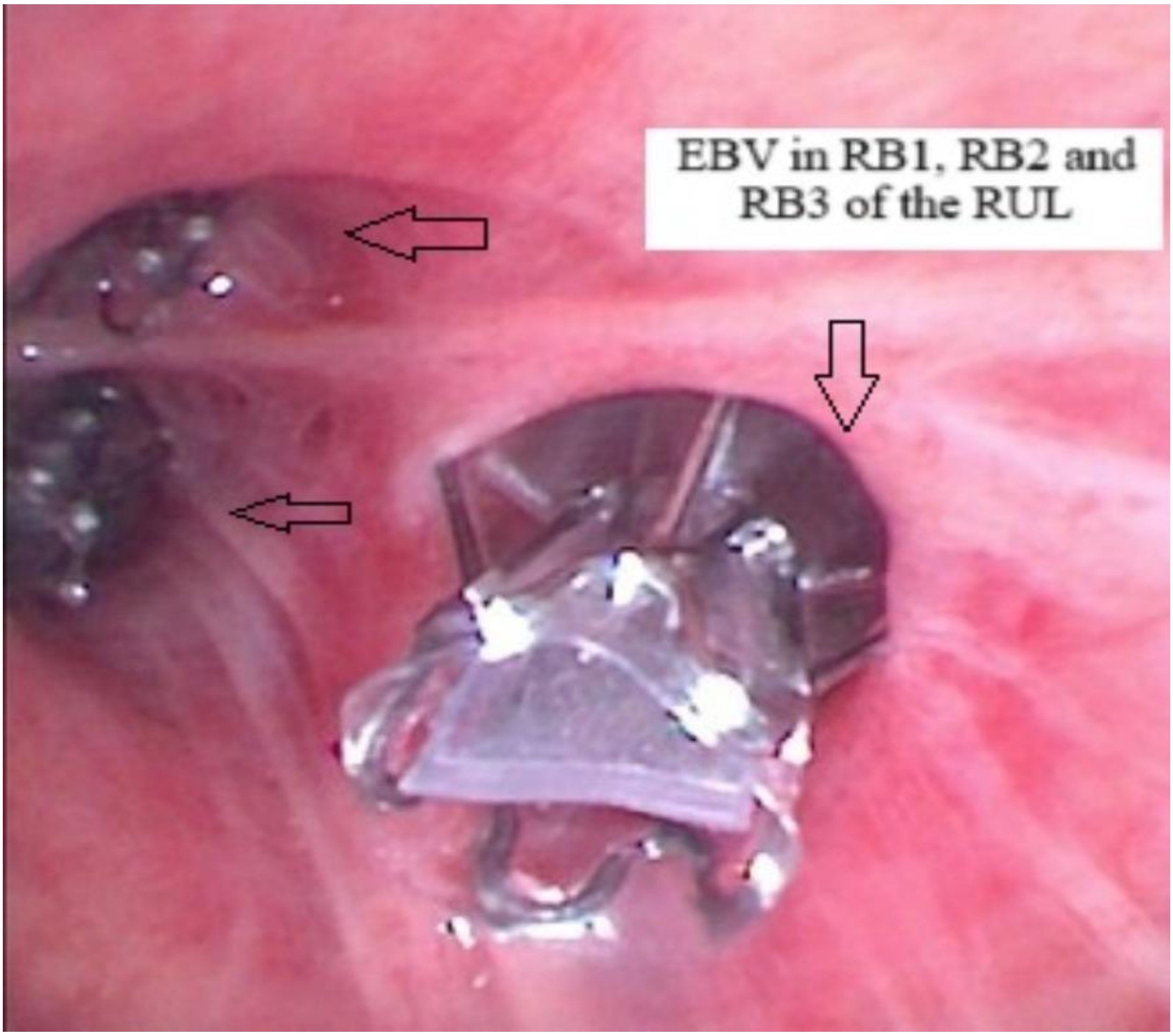

Figure 7: EBVs placed in the right upper lobe segments (Arrows)

Figure 8: Chest radiograph showing good expansion of the right lung post-second EBV insertion with right upper lobe collapse

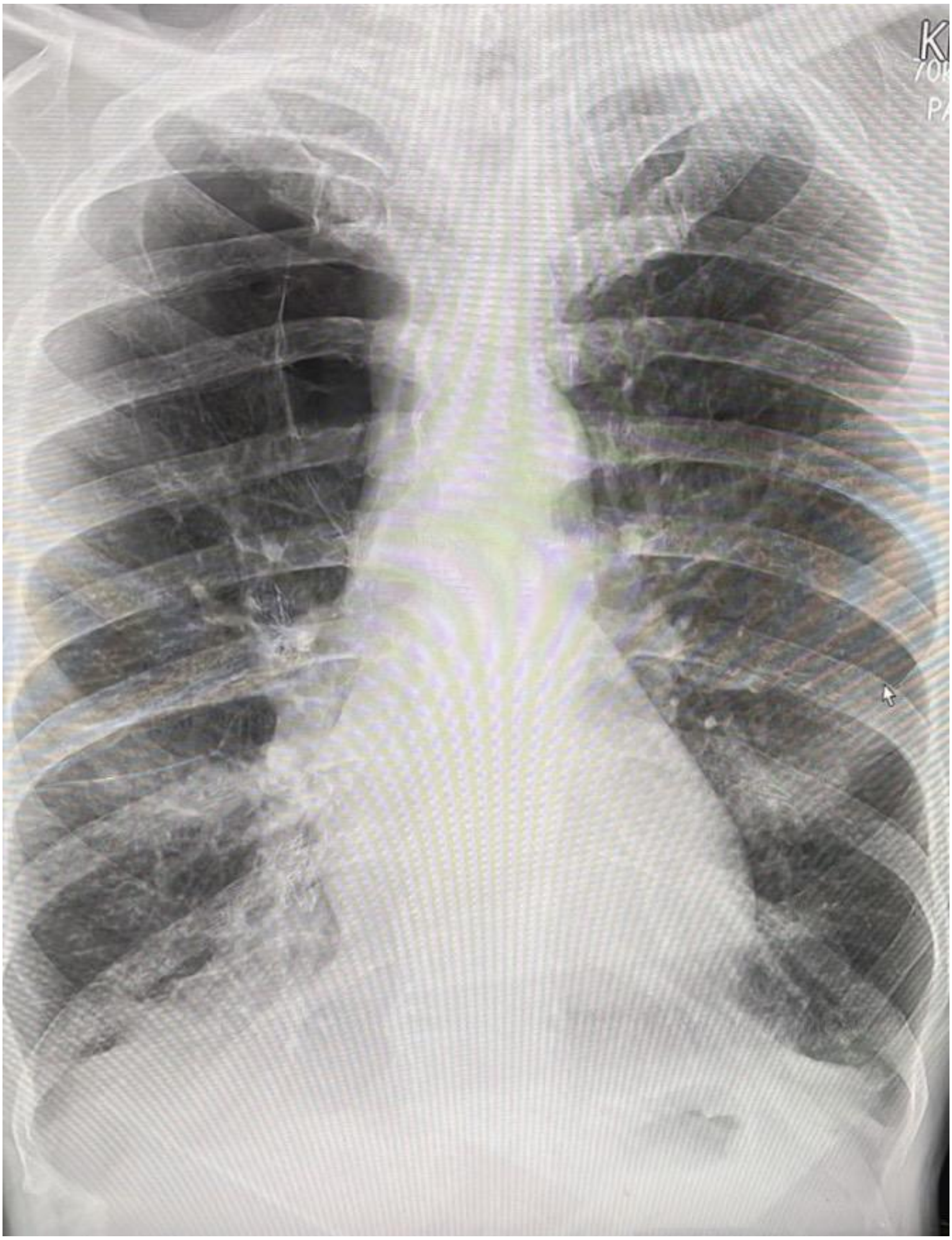

Figure 9: Chest radiograph image 4 weeks post-removal of intercostal drain shows good expansion of bilateral lung fields and no evidence of air leak