



Two Cases of Tension Pneumothorax during Hyperbaric Oxygen Therapy for Iatrogenic Air Embolism after Pulmonary Biopsy

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Iatrogenic air embolism is an increasingly common complication of various invasive procedures. Systemic air embolism (SAE) can manifest as a catastrophic event with coronary or cerebral artery occlusion. Emergency hyperbaric oxygen therapy (HBOT) is an effective and lifesaving treatment for SAE. However, it is not complication-free. Tension pneumothorax during HBOT is a rare but lethal complication. Here, we present two cases of SAE after percutaneous pulmonary core-needle biopsy, both of which were successfully treated with HBOT. The first case was complicated by iatrogenic tension pneumothorax during the decompression phase. The near fatality caused us to change our treatment protocol, and of the second case, encountered just the next month, was successfully completed without sequelae. The identification of patients at high risk for tension pneumothorax and the placement of a pulmonary drainage unit before HBOT for such patients can decrease the risk of tension pneumothorax during the decompression phase. Thus, HBOT remains the treatment of choice for the management of air embolism after invasive procedures or trauma in the thorax.

Key words: air embolism, hyperbaric oxygen therapy, pulmonary drainage unit, tension pneumothorax, pulmonary biopsy

Introduction

Iatrogenic air embolism is an increasingly common complication of a variety of invasive procedures, including percutaneous lung

biopsy, gas-insufflation laparoscopic surgery, open-heart surgery, and positive pressure ventilation.¹⁻⁴ Its incidence may be underestimated and underreported, and systemic air embolism (SAE) may manifest as a catastrophic event with coronary or cerebral artery occlusion^{2,5}

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with high morbidity (13% – 71%) and mortality (5% – 23%) rates.³ Emergency hyperbaric oxygen therapy (HBOT) is an effective and lifesaving treatment for SAE.^{2,5,6} However, HBOT is not complication-free, with eardrum barotrauma being the most commonly reported complication. Tension pneumothorax during HBOT is a rare but lethal complication with an incidence of 0.00045%,^{5,7} and it is strongly correlated with antecedent trauma or invasive pulmonary procedures. Here, we present two cases of SAE after percutaneous pulmonary core-needle biopsy that were successfully treated with HBOT, although the first case was complicated by iatrogenic tension pneumothorax during the decompression phase. The nearly fatal outcome resulted in a change in our treatment protocol, including the use of pleural drainage units (PDUs), which may have saved the life of the next patient.

Case Report

The first patient was a 78-year-old man with adenocarcinoma of the right upper lung lobe. A new nodule was detected in the left upper lung lobe, and a computed tomography (CT)-guided core-needle biopsy was scheduled for histological confirmation. The patient experienced chest tightness immediately after the procedure, and multiple air bubbles were identified in the left ventricle and ascending aorta by a radiologist (Fig. 1A & 1B). The patient was immediately transferred to the emergency department for oxygen administration and intensive monitoring. The hyperbaric oxygen center was contacted to prepare for emergency compression. The patient was placed in a hyperbaric oxygen tank 2 hours after the episode and treated according to the U.S. Navy Air Treatment Modified Table 5A (165 ft/185 min). The entire treatment course was uneventful, and the patient satisfactorily tolerated the treatment. However, although the air bubbles had all been absorbed upon subsequent chest CT, the treat-

ment course was complicated by left tension pneumothorax and a collapsed left lung (Fig. 2). A pulmonologist was consulted, and an indwelling pigtail drainage tube was inserted. The

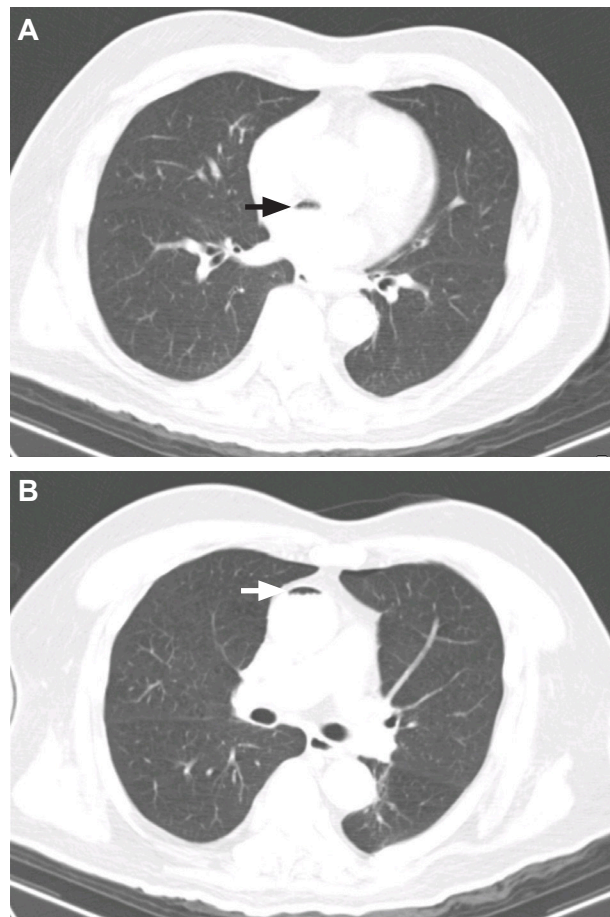


Fig. 1 Air bubbles in the left ventricle (A) and ascending aorta (B) are noted after computed tomography-guided biopsy.

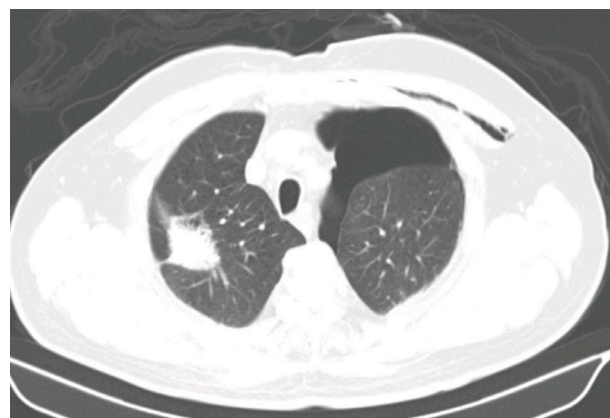


Fig. 2 Computed tomography shows left tension pneumothorax after hyperbaric oxygen therapy in the first case. The patient did not feel chest tightness or dyspnea at that time.

tension pneumothorax resolved, and the patient was discharged 1 week later. The treatment could not be considered successful because the unexpected tension pneumothorax in the hyperbaric oxygen tank could have been lethal.

Two months later, we encountered another case of iatrogenic air embolism. The 74-year-old woman was admitted for a scheduled CT-guided biopsy of a nodule of the right upper lung lobe. The treatment course was complicated by vigorous coughing and hemoptysis after the procedure. An air embolism was discovered in the patient's left ventricle and she was immediately transferred to the emergency room (Fig. 3). An indwelling pleural drainage device (chest tube) was inserted before the patient was transferred to the hyperbaric oxygen center for emergency compression, performed according to U.S. Navy Air Treatment Modified Table 5A. The treatment course was uneventful. Follow-up CT revealed no residual air bubbles and that the chest tube was effective, with minimal residual air in the right pleural space (Fig. 4). The patient recovered well and was discharged 1 week later without any sequelae.

Discussion

Iatrogenic air embolism may occur as a result of various invasive procedures. Clinical symptoms range from minor chest tightness to more lethal conditions. Emergency HBOT is an effective and life-saving treatment; however, it is associated with several complications. Regge *et al.* reported two cases of concomitant air embolism and tension pneumothorax that were successfully treated with HBOT.⁸ The prevalence of tension pneumothorax during HBOT has not been well documented. The largest series was reported by Toklu *et al.* in 2008, who surveyed European HBOT centers for pulmonary barotrauma. The incidence was calculated as 0.00045%.^{5,7} In another small series of patients who experienced tension pneumothorax during HBOT, most patients



Fig. 3 The left ventricle shows an air bubble after computed tomography-guided biopsy.

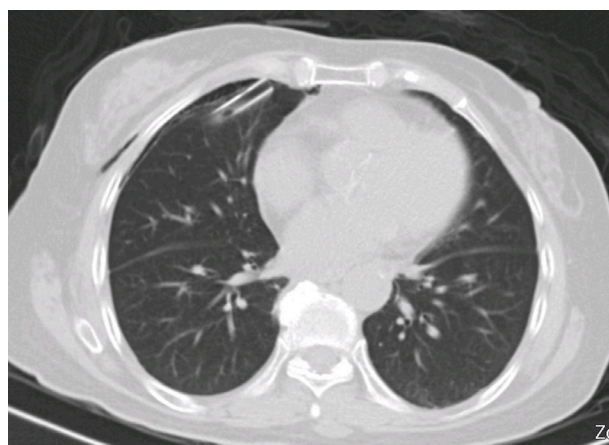


Fig. 4 An indwelling pleural drainage device (chest tube) is inserted before transfer of the patient to the hyperbaric oxygen center for emergency compression. Follow-up computed tomography reveals no residual air bubbles, which indicates that the chest tube was effective, with minimal residual air in the right pleural space.

had undergone cardiac resuscitation before HBOT; chest compressions might have caused minor thoracic trauma, and the risk of tension pneumothorax might have been increased during the decompression phase of HBOT.⁹ The most common predisposing risk factors for barotrauma during HBOT include pulmonary bulla formation, airway obstruction (caused by infection, sputum impaction, chronic obstructive pulmonary disease, and acute respiratory distress), breath-holding during the decompression phase, positive pressure ventilation, and antecedent pulmonary trauma (traumatic

or iatrogenic). Both patients in our report experienced iatrogenic air embolism after CT-guided pulmonary biopsy. We believe that the procedure caused air leakage during the decompression phase, which resulted in tension pneumothorax in the first case. Despite the uneventful recovery after emergency pigtail catheter decompression, the risk of barotrauma after any invasive procedure was re-evaluated in all our departments. We screened the literature and discovered that insertion of a pleural drainage device is effective and safe for high-risk patients in a hyperbaric oxygen tank under 4 – 6 atmosphere absolute (ATA).¹⁰ The estimated air-leak rate under positive pressure ventilation in animal models are as high as 1 – 16 L/min. With an air leak of 5 L/min or more, a suction setting of 10 cmH₂O or greater should be applied to prevent pressure accumulation in the intrapleural space.¹⁰ Use of a PDU with a Heimlich valve or a 30 cmH₂O water seal is recommended in the event of an emergency or in patients at high risk of tension pneumothorax. The effect of delayed initiation of HBOT can even be partially reversed by increasing the number of treatment sessions.³ Therefore, the treatment protocol in our institution was modified to the recommended use of a PDU before patients who underwent invasive procedures in the thorax or experienced thoracic trauma enter the tank. As a measure against any emergency, appropriate devices for emergency decompression were also stored in the HBOT chamber.¹¹ In the second case, iatrogenic air embolism after CT-guided lung biopsy was successfully treated without complications after antecedent chest tube placement according to our modified treatment protocol, and the patient was discharged without sequelae.

Conclusions

We presented a case of iatrogenic air embolism successfully treated by HBOT and highlight the importance of identifying patients

at risk of tension pneumothorax and the placement of a PDU before HBOT. Medical attendants should be present during the treatment of high-risk patients. With early identification of high-risk patients and PDU application, HBOT remains the treatment of choice for the management of air embolism after invasive procedures or trauma. We believe that our experiences will help other medical institutions facing such complications, improving patient safety.

Author Contributions

The emergency compression protocol was established and modified by Jih-Hsi Yeh, Chin-Shien Wu, Li-Jen Yuan, and Yi-Chen Li. The insertion of the emergency indwelling pigtail catheter in the first case to treat tension pneumothorax was performed by Jiun-Rung Chen. All the images and the manuscript were revised by Yu-Hsi Kao. Yi-Chen Li is the corresponding author who was in charge of the two patients during their hospital stay. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Ethical review and approval were waived for this case report.

Informed Consent Statement

The patients provided consent to undergo the treatment. Written informed consent has also been obtained from the patients to publish this paper.

Data Availability Statement

Not applicable.

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Conflicts of Interest

The authors declare no conflict of interest.

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