Systemic Air Embolism following Percutaneous Lung Biopsy

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Systemic air embolism is a serious complication that may occur during a transthoracic percutaneous lung biopsy. Although rarely encountered, sequelae from systemic air embolism may result in a wide range of cardiac and neurologic presentations that are potentially fatal. Prompt clinical and radiologic recognition of systemic air embolism can prevent significant morbidity and mortality. The authors performed a transthoracic percutaneous lung biopsy that was complicated by seizures and transient neurologic deficits. In this article, a case of percutaneous lung biopsy complicated by a systemic arterial air embolism is presented, and strategies for prevention and management of this complication are discussed.

Case Report

A 75-year-old woman with a longstanding history of smoking, hypertension, and severe chronic obstructive pulmonary disease (forced expiratory volume of 0.8 L) underwent thoracic computed tomography (CT) that identified an enlarging 7-mm pulmonary nodule in the left lower lobe (►Fig. 1A). Given the patient's history and imaging characteristics, a percutaneous lung biopsy was recommended.

With the patient prone and sedated, a 5.0-cm coaxial 20-gauge/22-gauge core biopsy set was used to access the left lower lobe nodule. Intermittent CT scanning was performed to confirm an appropriate trajectory, and several passes were made into the lesion with adequate tissue sampling. The authors' standard practice is to use a water-seal technique (i.e., injecting water into the coaxial needle during inner needle exchanges) to fill any potential space caused by differences between intrathoracic and atmospheric pressure. After the last biopsy pass, the 22-gauge stylet was removed, and the patient began to cough forcefully, expelling the saline column from the coaxial needle. Air whistling was

heard as it entered the coaxial needle. An immediate CT scan of the chest was performed while awaiting cytologic assessment of the specimen. The CT images showed perilesional hemorrhage and gas within the aorta (►Fig. 1B, C).

The patient had a grand mal seizure, at which point the needle set was removed and the patient was turned supine; a code was initiated as the patient was unresponsive. She had periods of wakefulness but became increasingly disoriented, agitated, and she developed respiratory distress requiring intubation and ICU observation. Subsequent CT scans of the head and chest revealed no evidence of residual gas within the arterial or venous systems.

The patient was intubated for less than 24 hours. After being extubated, she had a complete recovery and was discharged home in stable condition 48 hours after the procedure.

Discussion

CT-guided percutaneous transthoracic biopsy of the lung is a well-established technique for definitive diagnosis of pulmonary nodules. The reported incidence of systemic air embolism is 0.02 to 0.07% and is associated with a significant morbidity and mortality.^{1,2} The true incidence of this complication is likely higher because of undiagnosed asymptomatic patients and underreporting. Clinical symptoms from air embolism typically arise from the ischemic effects of gas within the coronary and cerebral circulations.³

Independent risk factors for systemic air embolism include penetration depth into the tumor, endotracheal anesthesia, level of the lesion above the left atrium (in a nondependent position), and prone positioning. Other proposed risk factors include acute angle of the needle to the tumor surface, number of biopsy samples, penetration depth of the cutting needle, and a basal position of the lesion.⁴

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Figure 1 Systemic arterial air embolism following percutaneous lung biopsy. (A) Preprocedural imaging demonstrated a suspicious nodule in the left lower lobe. (B) A 5.0cm coaxial 20-gauge/22-gauge core biopsy set was advanced into the lesion with subsequent hemorrhage identified. (C) Air is identified within the aorta and the spinal arteries (arrows).

There are three proposed mechanisms for air entering the systemic circulation. First, air can enter in the systemic circulation via communication between the pulmonary vein and the atmosphere. The second mechanism is via a bronchovenous fistula or other communication between air-containing spaces and pulmonary veins. The third mechanism may occur when air from the pulmonary arterial system reaches the pulmonary venous circulation by traversing the pulmonary microvasculature.⁵ While systemic air embolism cases may be asymptomatic, as in this case, some cases present suddenly with changes in mental status or seizures.

In this particular case, the authors believe air was introduced into the pulmonary vein via the conduit between the atmosphere and pulmonary vein provided by the needle access. The authors' standard practice is to use the water-seal method when removing the inner stylet to fill any potential space created by the difference between intrathoracic and atmospheric pressures. In this case, at the time of the last biopsy pass, the patient's forceful coughing caused expulsion of the saline column from the coaxial needle system. On the immediate subsequent scan, perilesional pulmonary hemorrhage and gas in the aorta were seen; therefore, that the proposed mechanism in this case is a communication between atmospheric gas and the pulmonary venous system, leading to systemic arterial air embolism.

Prompt recognition of systemic air embolism is crucial because simple temporizing measures may lead to resolution. Systemic air embolism may be asymptomatic, but as little as 2 mL of air in the cerebral circulation can be fatal, and 0.5 to 1.0 mL of air injected into the pulmonary veins can cause coronary embolism and lead to cardiac arrest.⁶ The treat-

ments for an arterial air embolism versus a venous air embolism differ. For a venous air embolism, the primary treatment is supportive therapy consisting of supplemental oxygen administration, intravascular volume expansion, and blood pressure support. The patient should then be placed in Trendelenburg or left lateral decubitus position to trap the air in the left atrium. Prevention of further gas entry by measures to increase venous pressure such as aggressive intravenous fluid administration may be attempted.^{7,8}

If an arterial embolism is suspected, the source for gas entry must be completely removed. The patient should then be placed in the right lateral decubitus position to prevent air from entering the systemic circulation by keeping the left ventricular outflow tract in a nondependent position away from the aorta; this maneuver will trap air in the left ventricle. After providing supportive measures, hyperbaric oxygen therapy has been shown to be effective as a first-line therapy to promote the exchange of oxygen for nitrogen in the air bubbles.^{7,9-11}

It is essential that interventional radiologists comprehensively understand not only clinical treatment algorithms but also potential complications such as intravascular air, as gas embolism is likely more prevalent than reported. Early recognition of systemic air embolism is crucial in decreasing morbidity and mortality. In a companion case presented here (►Fig. 2), another patient also ultimately had a good outcome from a potentially fatal complication. In spite of observing standard precautions, rare cases of systemic air embolism occur and may be seen more often in the future, as the number of imaging examinations and image-guided procedures performed increases.

Figure 2 Thoracic computed tomographic scan of a different patient as part of the workup for a known left lower lobe pulmonary nodule. Systemic venous air embolism following accidental injection of ~120 mL of air through a power injector. (A) Air is identified within the pulmonary artery. (B) A left lower lobe pulmonary nodule and air within the right ventricle are noted. The patient was completely asymptomatic.

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