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CASE REPORT

Cerebral air embolism treated with hyperbaric oxygen therapy following percutaneous transthoracic computed tomography-guided needle biopsy of the lung

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Abstract A 71-year-old man presented with cough and sputum for 12 months. Chest radiography showed a homogeneous opacity in the right lower lobe. Computed tomography (CT) showed a nodular opacity, 2 cm in diameter, in the posterior segment of the right lower lobe. Mild emphysematous changes were also seen. With the patient in a prone position, a 19-gauge 7.8-cm introducer was placed in the lesion during a single inspiratory breath-hold. A coaxial 20-gauge automated needle was inserted through the introducer using a biopsy gun. Although the patient did not complain of any symptoms, postbiopsy CT showed air in the left ventricle and ascending aorta. After 5 h of bed rest, we found weakness in his left lower extremity. He was transferred to a hyperbaric oxygen chamber and recovered the next day. Air embolism is a rare, potentially fatal complication of percutaneous lung biopsy. Although the true effect of hyperbaric oxygen therapy is controversial, knowledge regarding the prompt management of such cases may help radiologists who perform this procedure.

Key words Air embolism · CT-guided needle biopsy · Lung

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Introduction

Computed tomography (CT)-guided percutaneous needle biopsy is an established procedure for histological diagnosis of pulmonary lesions. However, the procedure is associated with various complications—including simple pneumothorax, self-limiting hemoptysis, life-threatening pulmonary hemorrhage and air embolism—although severe complications such as the latter are rare. We report a case of cerebral air embolism following CT-guided percutaneous needle biopsy of the lung.

Case report

A 71-year-old man with a 7-year history of angina pectoris presented with cough and sputum for 12 months. Chest radiography performed by his family physician showed a homogeneous opacity in the right lower lobe. The patient was referred to our hospital for further examination. A CT scan showed a nodular opacity, 2 cm in diameter, in the posterior segment of the right lower lobe (Fig. 1). No hilar or mediastinal adenopathy was present. Mild emphysematous changes were also seen on CT. Lung cancer was suspected and a CT-guided needle biopsy was requested by a pneumonologist. After written informed consent was obtained, the biopsy was performed under CT guidance.

The patient was placed in a prone position, and the lesion was localized with CT. A 19-gauge, 7.8-cm introducer (Coaxial Introducer Needle; Medical Device Technologies, Gainesville, FL, USA) was placed in the lesion during a single inspiratory breath-hold. The position of the introducer was not changed until the end of the procedure. A coaxial 20-gauge automated needle

(SACN Biopsy Needle, Medical Device Technologies) was inserted through the introducer, and a core specimen was obtained using a biopsy gun (Fig. 2). The specimen was submitted for pathological analysis in formalin after touch preparation by a cytopathology technologist in the CT suite. Following the core biopsy, aspiration cytology was performed with a coaxial 22-gauge needle (Wescott Biopsy Needle; Medical Device Technologies). The 19-gauge needle stylet of the introducer was inserted between each biopsy session. The patient was entirely cooperative during the procedure without coughing or deeply breathing.

After removal of the needle the patient was turned to the supine position, and a post-biopsy CT scan was performed. It showed air in the left ventricle and ascending aorta (Fig. 3). An increase in blood pressure from 149/85 mmHg to 200/110 mmHg was observed. His conscious level was normal, and no cardiac or neurological symptoms were observed. There was no change in the electrocardiogram (ECG) monitor or in SaO_2. The patient was placed in the Trendelenburg position and 100% oxygen was administered. A CT scan obtained 30 min later showed disappearance of the air in both the left ventricle and aorta. During 3 h of bed rest, he remained asymptomatic.

Because the repeat chest CT showed no air in the cardiovascular system, the patient was released from bed rest. When he started walking, he noticed weakness in

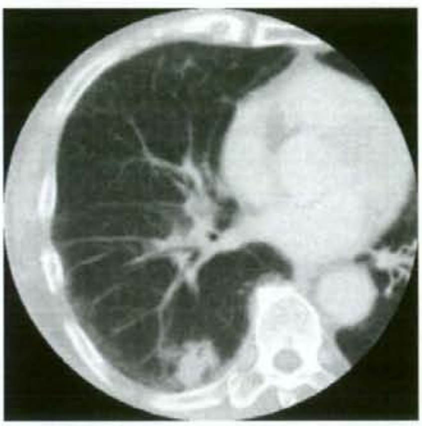

Fig. 1. Computed tomography (CT) scan before biopsy revealing a nodular opacity, 2 cm in diameter, in the posterior basal segment of the right lower lobe

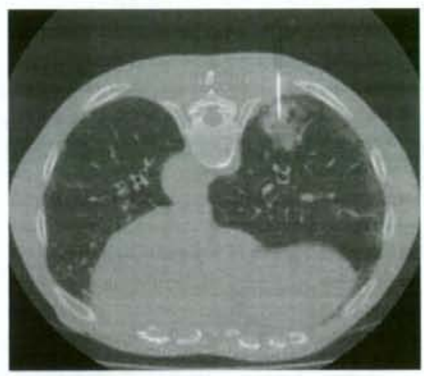

Fig. 2. CT scan obtained during biopsy. A 19-gauge, 7.8-cm introducer was placed in the lesion. The tip of the introducer is not visualized. A coaxial 20-gauge automated needle was inserted through this introducer, and a core specimen was obtained using a biopsy gun

Fig. 3. CT scan obtained after biopsy. The patient was turned to the supine position after removing the needle. **A** CT scan at the level of the ascending aorta showing intraluminal air. **B** CT scan at the level of the ventricle showing air bubbles in the left ventricle

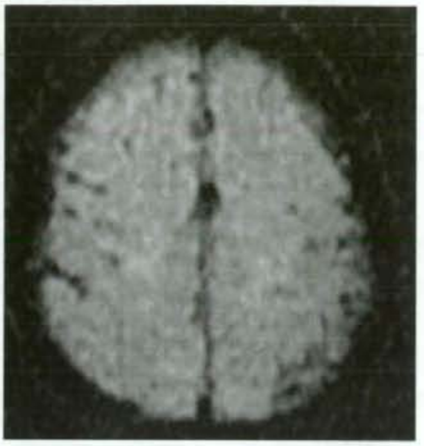

Fig. 4. Emergency diffusion-weighted image of the brain. No sign of infarction was identified

his left lower extremity. Emergency magnetic resonance imaging (MRI) of the brain was performed including diffusion-weighted images (Fig. 4), and it revealed no abnormalities. We surmised that there was an embolism at the level of a small arteriole. He was transferred to the hyperbaric oxygen chamber soon after MRI (5 h after the biopsy) and received hyperbaric oxygen therapy for about 5 h at 1.9–2.8 atm. His neurological deficit disappeared the next day. No further imaging studies were performed. Four days after the event, he was discharged without neurological deficit. One year after treatment, he is under observation following treatment for squamous cell carcinoma of the lung.

Discussion

We usually use an 18-gauge biopsy system for percutaneous lung biopsy to obtain more tissue than can be obtained with a fine needle, but there is a possibility of increased complications. Complications of CT-guided percutaneous needle biopsy include pneumothorax, hemothorax or hemoptysis, tumor dissemination, and air embolism. Of these complications, pneumothorax is the most frequent. Tomiyama et al. reported the incidence of pneumothorax to be 35% among 9783 biopsies. They noted that life-threatening complications occurred in 0.75% of patients, including a 0.061% incidence of air embolism.[1] Sinner also reported the incidence of air embolism as 0.070% among 2726 biopsies.[2]

The mechanism of air embolism is only speculation. Possible mechanisms of the influx of air into the systemic circulation include following: First, when the needle tip is placed in the pulmonary vein followed by removal of the stylet, a direct communication between the atmosphere and the pulmonary vein is created. Air can easily enter the systemic circulation if the patient inhales and would result in negative intrathoracic pressure. Second, a bronchovenous fistula can be created when the needle passes through the lung parenchyma. Intraalveolar or intrabronchial air may be introduced into the pulmonary venous circulation through the fistula. A Valsalva maneuver, cough, or positive-pressure ventilation increases air introduction by elevated intraalveolar pressure. Third, air may be introduced in the pulmonary arterial circulation and later reach the pulmonary venous circulation by traversing the pulmonary microvasculature.[3–7] The patient in the present report did not take any deep breath, hold his breath, or cough. We speculate that the mechanism of air embolism in our patient was a transient bronchovenous fistula along the needle tract.

Air in the pulmonary vein goes directly into the left atrium and ventricle and eventually enters the systemic circulation, resulting in ischemia in any of various organs. Presumed mechanisms are obstruction of the artery by air, vasospasm during the passage of air, platelet activation by the air, and microthrombus formation.[6] First, an air embolism can obstruct the blood flow directly. Second, it causes intense vasospasm while passing through the vessel. Finally, vascular endothelial damage is caused by an air embolus, which can induce platelet activation with microthrombus formation leading to further ischemia.[8,9]

An air embolus presents in various ways depending on the occluded artery. Cerebral embolism causes sudden consciousness disturbance, convulsions, hemiplegia, dysarthria, and visual impairment. Coronary artery embolism develops shock, cardiac arrest, cardiac arrhythmia, and ischemia that can be induced by three mechanisms.

Use of positional therapy, such as the Trendelenburg or left lateral decubitus position, is controversial and may be more helpful for treating shock induced by right ventricular air emboli. It is currently recommended that patients with arterial gas embolisms be placed in the flat supine position because it is easy to administer various lifesaving treatments.

The treatment of systemic air embolism consists of supplying 100% oxygen by a tight-fitting mask or endotracheal intubation to promote the exchange of nitrogen for oxygen in the air bubble.[1,10] In addition, hyperbaric oxygen is considered to be the first-line treatment of choice for arterial gas embolism.[11–13] With hyperbaric oxygen therapy, the patient breathes 100% oxygen at a pressure above that of the atmosphere at sea level. It theoretically decreases the size of the gas bubble by both raising the ambient pressure and causing systemic hyperoxia. The hyperoxia produces enormous diffusion gradients for oxygen to move into the bubble and for nitrogen to move out. The hyperoxia also allows much larger quantities of oxygen to be dissolved in the plasma and increases oxygen diffusion in tissues. The improved oxygen-carrying capacity of plasma and delivery of oxygen to tissues may offset the embolic insult to the microvasculature. It may also help prevent cerebral edema by reducing the permeability of blood vessels while supporting the integrity of the blood–brain barrier. Furthermore, experiments have suggested that hyperbaric oxygen diminishes adherence of leukocytes to damaged endothelium. These benefits suggest that all patients with clinical symptoms of arterial gas embolism should undergo recompression treatment with hyperbaric oxygen.

Air embolism may be prevented by avoiding needle biopsies of cystic, cavitary, or bullous lung parenchyma. In addition, a stylet or occlusion of the hollow needle at all times can prevent direct communication between the atmosphere and pulmonary venous system. The patient should refrain from coughing or straining while the mass is being biopsied, especially when the stylet has been removed. It is crucial to select an insertion site where the needle penetrates the least amount of lung parenchyma to reach the mass. Performing the biopsy under CT-guided fluoroscopy may decrease the incidence of this complication.[14]

In our case, the patient developed neurological deficits with no abnormal signal on MRI including a diffusion-weighted sequence. We may have been able to confirm the air embolus by CT, but it is often too small to be detected. Air in the systemic circulation may be observed even without any symptoms, and prophylactic treatment is controversial. In one series of four patients, hyperbaric oxygen was administered to two patients with no neurological complications, and they did not develop any serious complications.[15] We administered treatment by hyperbaric oxygen after the patient became symptomatic, resulting in recovery of the patient. Although its effectiveness with prophylactic use, as well as with treatment after the patient is symptomatic, is still uncertain because an air embolism may disappear even without such treatment, hyperbaric oxygen therapy is theoretically a reasonable treatment if available.

Complications of hyperbaric oxygen treatment include oxygen toxicity to the brain and lungs and barotrauma to the ears, paranasal sinuses, and lungs. However, serious complications are rare if the procedure is properly performed. Radiologists should be aware of these complications and be knowledgeable regarding prompt management.[7,16–18]

In the case of needle biopsy of the lung, we include air embolism in the list of complications even though it is rare.

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