JOURNAL OF FORENSIC SCIENCES

*J Forensic Sci,* July 2012, Vol. 57, No. 4
doi: 10.1111/j.1556-4029.2012.02094.x
Available online at: onlinelibrary.wiley.com

**CASE REPORT**

**PATHOLOGY/BIOLOGY**

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# Fatal Paradoxical Air Embolism Diagnosed by Postmortem Imaging and Autopsy

**ABSTRACT:** The recognition and visualization of an arterial gas embolism are difficult. We report a case of sudden death caused by paradoxical air embolism of coronary and cerebral arteries, diagnosed by the pre autopsy computed tomography (CT) scanning. A 54-year-old woman suddenly died after the self-removal of the jugular vein catheter. Postmortem imaging examination using CT scanning showed multiple gas embolisms in the cerebral arteries, pulmonary artery, right atrium and ventricle, left ventricle, aorta, and coronary arteries. These findings suggested that the occurrence of acute ischemia of the brain and heart caused by massive air inflow to the artery. Conventional autopsy revealed a patent foramen ovale of the heart. These results indicated that the patient died of paradoxical air embolization of the coronary and cerebral arteries through a patent foramen ovale because of right-to-left shunting. The use of postmortem imaging as an aid for conventional autopsy has proved to be of advantage in the case of gas embolism.

**KEYWORDS:** forensic science, paradoxical air embolism, postmortem imaging, patent foramen ovale, central venous catheter removal

Postmortem computed tomography (CT) examination is utilized in the field of forensic pathology because it can be used to assess causes of death, injury, and for personal identification (1,2). CT examination before autopsy is able to provide not only information to guide the autopsy, but also significant findings to analyze the cause of death, which may not be possible in autopsy (3,4). Especially, the recognition of an arterial gas embolism is difficult employing normal X-ray and traditional autopsy. We report a case of sudden death caused by paradoxical air embolism of the coronary artery, diagnosed by postmortem CT scanning.

## Case Report

A 54-year-old woman was referred from an emergency unit for a complex necrotic ulcer of the right hand with high fever. She had received hemodialysis because of lupus nephritis for 34 years, through a blood access shunt in the right elbow. She had been treated for gangrene of the right hand for 6 weeks, which had started to 2 weeks earlier. However, she showed a relapse of gangrene, which became worse over the course of 1 day. She required immediate amputation of the infected hand and intensive care, because septic shock caused hypotension (68/37 mm Hg). Thus, a double-lumen 7 F catheter was placed in the right internal jugular vein for perioperative hemodynamic management. The patient's condition improved after these treatments.

On postoperative day 6, the patient removed the central venous catheter by herself on sitting in an upright position. After removal of the catheter, she lost consciousness within 5 min, developed cardiopulmonary instability, and then cardiac arrest. She was pronounced dead immediately after resuscitation efforts failed.

### *Postmortem Imaging Findings*

Before autopsy, postmortem imaging examination using a CT scan was performed 1 h after the patient died. Brain CT scan showed broad areas of cerebral arterial gas. Chest CT scan showed gas in the pulmonary artery right atrium and ventricle (Fig. 1), left ventricle (Figs 1 and 2), aorta, and coronary arteries, with air remaining in the aorta (Fig. 1). These findings suggested the occurrence of acute ischemia of the brain and heart caused by massive right-to-left air inflow to the brain and coronary arteries.

### *Autopsy Findings*

Autopsy was performed on the day of death. It confirmed a patent foramen ovale, considered responsible for the paradoxical air embolism (Fig. 3). Microscopically, severe amyloidosis associated with hemodialysis was observed in the pulmonary arteries, lungs,

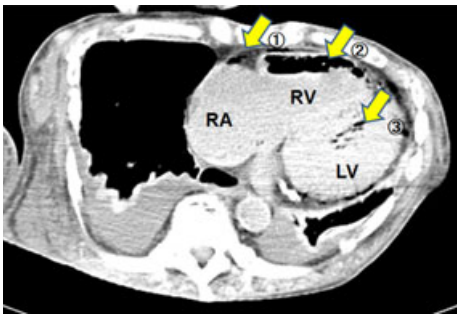


FIG. 1—*Postmortem chest computed tomography shows gas in the right atrium (arrow 1), right ventricle (arrow 2), and right ventricle (arrow 3).*

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Received 16 Dec. 2010; and in revised form 9 April 2011; accepted 19 June 2011.

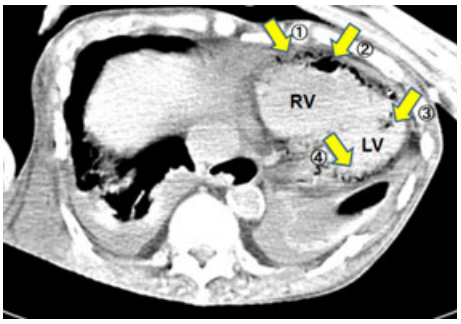


FIG. 2—*Postmortem chest computed tomography shows gas in the right coronary artery (arrow 1), right ventricle (arrow 2), left ventricle (arrow 3), and left coronary artery (arrow 4).*

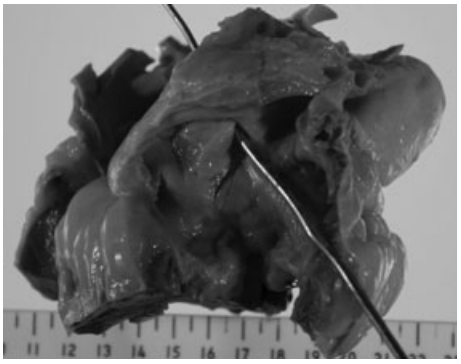

FIG. 3—*Picture at autopsy shows a patent foramen ovale.*

heart, liver, and kidneys. These results indicated that the patient died of paradoxical air embolism of the coronary artery through a patent foramen ovale.

## Discussion

Gas embolism occurs accidentally as a complication of invasive diagnostic and therapeutic procedures, including: direct air aspiration into the vein through a disconnected peripheral intravenous catheter, direct air injection, entrainment of air or gas from the operative field, and positive pressure ventilation (5–7). Most small venous air embolisms after minimal intravenous manipulations are of little concern, because small air emboli in the veins, right atrium, right ventricle, and the pulmonary trunk were found to be asymptomatic (8). When large amounts of air sufficient to block the cardiovascular system enter it, patients develop cardiovascular collapse or die. In such severe venous air embolism cases, even a plain erect chest X-ray may show the fluid level and gas in the cardiac ventricle, or a gas column in the jugular vein (9). On the other hand, arterial gas is more life-threatening because a small amount of arterial air can lead to cardiovascular collapse, neurologic sequelae, and even death (10,11). However, the recognition of arterial gas is difficult employing normal X-ray and traditional autopsy (12). Gas embolism of the coronary artery may be missed at autopsy even if opening of the heart is performed under water (5). If the gas embolism occurs in another body area, it will not be found on autopsy because no technique exists to recognize the intravascular gas (12).

Our patient was also diagnosed with coronary and cerebral arterial gas embolisms on postmortem CT scanning before autopsy. Air may be sucked into the central vein through the residual catheter tracts and then flow to the right atrium, right ventricle, and pulmonary artery. Autopsy confirmed a patent foramen ovale, considered as responsible for the paradoxical air embolism. Venous air emboli can paradoxically enter the arterial circulation through a patent foramen ovale. A patent foramen ovale, which is found in at least 25% of the general population, is usually functionally closed, unless the right exceeds the left atrial pressure, allowing right-to-left shunting (10). Thus, it is a potential route for emboli arising from the venous system to enter the systemic arterial circulation, resulting in paradoxical air embolism syndrome (10,13,14). Wu et al. (11) reported a similar case of paradoxical cerebral air embolization through a residual tract after the removal of a central venous catheter. In our case, right-to-left shunting probably occurred because the pulmonary arterial pressure rose because of severe amyloidosis of the pulmonary arteries and lungs and the upright position. Recognizing pathological gas on postmortem CT imaging is sometimes difficult because decompositional gas develops when the examination is delayed. We performed postmortem imaging about 1 h after the patient died, which avoid such postmortem artifacts. We conclude that immediate postmortem CT scanning for patients who have possibly died of air embolism is very useful as a guide for conventional autopsy.

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