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Case Report

A case of iatrogenic air bubbles in the left ventricle by coronary computed tomographic angiography

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ABSTRACT

We report a case of asymptomatic iatrogenic air bubbles in the left ventricle observed by coronary computed tomographic angiography. Air bubbles are rarely found in the left ventricle and could prove fatal should they migrate to the brain or coronary arteries. We believe that the cause is micro air bubbles in the tubing system between the intravenous catheter and power injector.

Introduction

We have often found small iatrogenic air bubbles in the right heart system (ie, the right atrium, right ventricle, and pulmonary artery) following contrast medium injection through a power injector in coronary computed tomographic (CT) angiography. Even though most cases of iatrogenic air bubbles are asymptotic, they can potentially lead to complications. The incidence of air bubbles associated with the injection of contrast medium for CT scans is 11%-23% according to previous reports [1–3]. However, air bubbles are rarely observed in the left ventricle and could prove fatal, particularly if they migrate to the brain or coronary arteries. We report a case with air bubbles in the left ventricle observed by coronary CT angiography.

Case report

A 60-year-old female outpatient presented with intermittent atypical chest pain. Coronary CT angiography was performed to evaluate coronary artery disease.

Competing Interests: **The authors have declared that no competing interests exist.**

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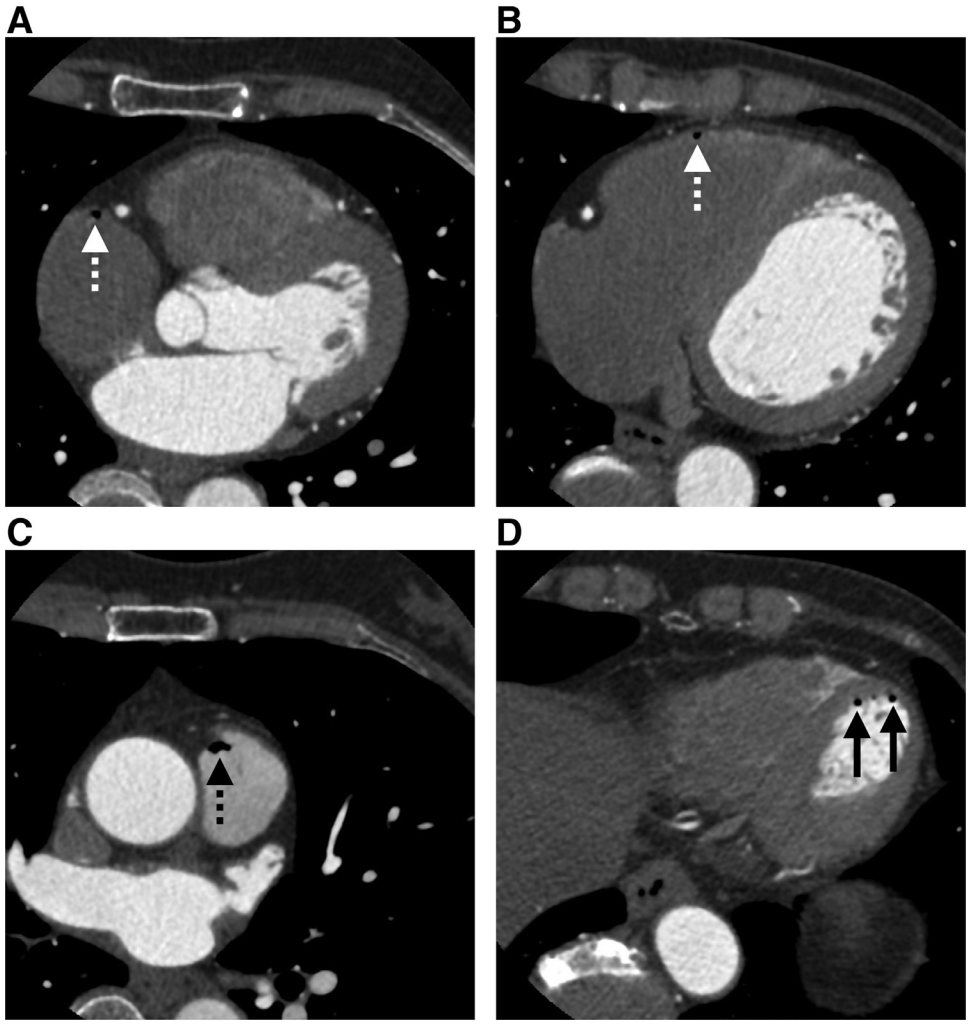

Fig. 1 – Air bubbles revealed in axial coronary CT images. (A) The right atrium (white arrow), (B) the right ventricle (white arrow), (C) the pulmonary artery (black arrow), and (D) multiple air bubbles (black arrows) in the left ventricle.

A 20-gauge intravenous catheter was inserted into the right antecubital basilica vein. Nonionic contrast medium iohexol (300 mgI/mL) (Omnipaque, Daiichi-Sankyo Co, Ltd, Tokyo, Japan) was administered with a dual power injector (DSGX-V, Nemoto-Kyorindo Co, Ltd, Tokyo, Japan). The flow rate and total volume of the contrast medium were 4.9 mL/sec and 59 mL, respectively. After this, 25 mL of a 0.9% saline solution was injected at the same flow rate. The optimized scan delay time was determined by the test injection method.

Coronary CT angiography was performed using a 64-row multislice CT scanner (Discovery CT750HD, GE Healthcare, Tokyo, Japan). The acquisition protocol included a gantry rotation time of 350 ms, a collimation width of 0.625 mm, a table feed speed of 18.3 mm/s, a tube voltage of 120 kV, and a current of 350 mA. An oral ß-blocker (50 mg of Atenolol; Tenormin, AstraZeneca, Osaka, Japan) was administered to reduce heart rate 1 hour before the examination; during the examination, her average heart rate was 57 beats per minute. The scan was performed while the patient held her breath after inspiration phase.

Axial images were retrospectively reconstructed at 75% of the R-R interval for each cardiac cycle, using a section thickness of 0.625 mm and an increment of 0.625 mm, with a standard kernel.

There were no side effects following administration of the intravenous contrast medium. However, multiple air bubbles were identified in the right atrium, right ventricle, main pulmonary trunk, and left ventricle (Fig. 1). The presence of a patent foramen ovale was confirmed by coronary CT angiography (Fig. 2). It took approximately 1 hour to reach final consensus about how to treat the patient and transfer her to an outpatient room; during the period, she was monitored with her spine position on the CT table. Then, she was monitored with her Trendelenburg position for another 3 hours. Subsequently, as we found no air bubbles in her heart on nonenhanced ECG-gated CT (Fig. 3), chest CT did not show an intrapulmonary shunt such as a pulmonary arteriovenous fistula, and there were no clinical symptoms; she was discharged without special clinical treatment.

Fig. 4 shows the timeline from the start of the CT examination to her discharge.

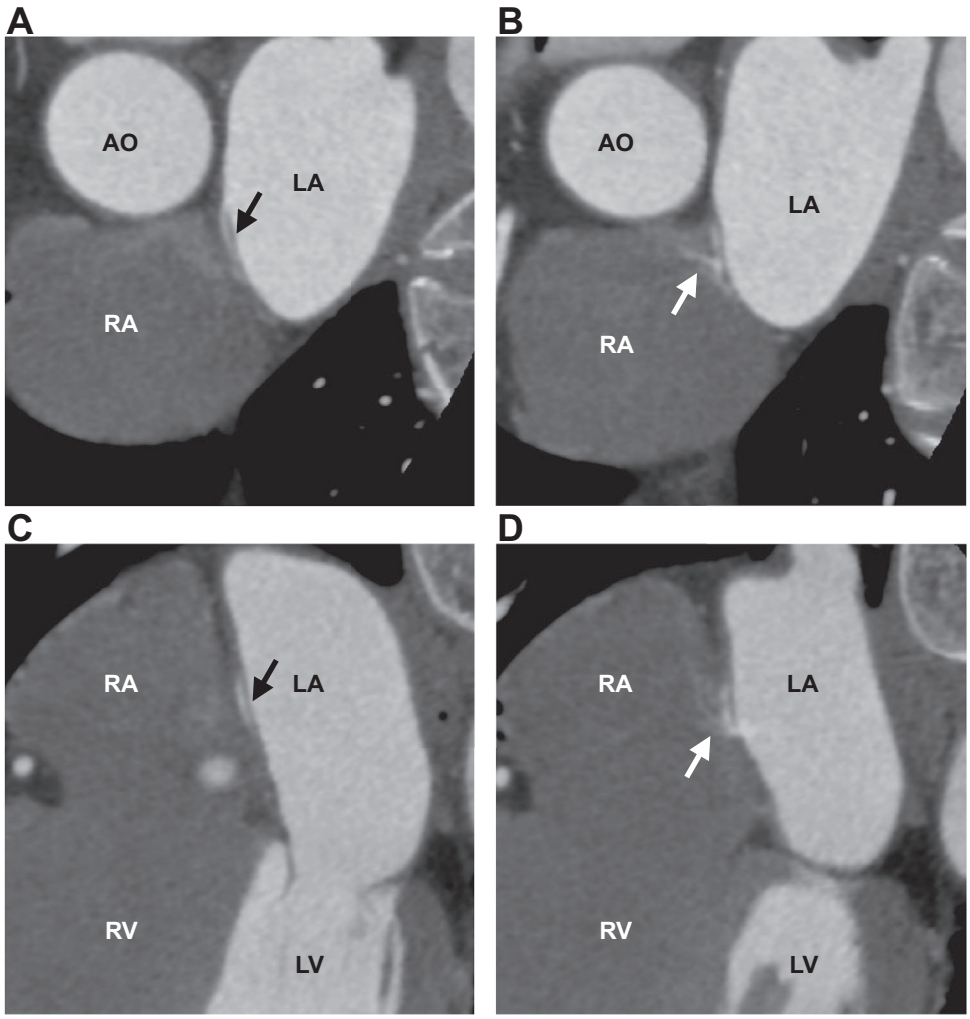

Fig. 2 – Findings typical of a patent foramen ovale. (A, B) Short-axis images demonstrate the slit-like contrast column appearance of the interatrial septum (black arrow in A) and contrast jets from the left atrium to the right atrium toward the inferior vena cava (white arrow in B). (C, D) Similarly, 4-chamber view images demonstrate the slit-like contrast column appearance of the interatrial septum (black arrow in C) and contrast jets from the left atrium to the right atrium (white arrow in D).

Discussion

Orebaugh noted that 3 elements must be present in order for air to be admitted into the vascular system: (1) a source of air (the atmosphere), (2) a connection between the vascular system and the air source, and (3) a pressure gradient that favors air entry [4]. Air can enter an open blood vessel when either of the following conditions exist: (1) a negative intravascular pressure relative to air pressure or (2) the air is under pressure and is pushed into vessels with or without a negative intravascular pressure [4,5]. We believe that the use of a power injector meets this second condition. Moreover, Groell et al reported that air can also be introduced into the vascular system during contrast administration during catheter insertion, when connecting the cannula to the injection tube, and through micro air bubbles in the contrast medium [2]. They proposed that careful handling of intravenous injections of contrast medium can avert the occurrence of iatrogenic air bubbles [2]. In the present case, we believe the original source of the iatrogenic air bubbles was micro air bubbles in the tubing system between the intravenous catheter and power injector.

Air in the venous and the right heart system can be introduced into the left heart and the arterial system if there is an intracardiac or intrapulmonary shunt. Of these, most common is the patent foramen ovale. Patent foramen ovale is common in the general population, with estimates from autopsy studies suggesting a prevalence of 25%-35% [6], and this may allow venous air bubbles to enter the arterial circulation, increasing risk [7,8]. In addition, the effect of holding the breath after deep inspiration during CT scanning may increase the right atrial pressure and thus may increase the flow across the patent foramen ovale [3]. Recent studies have reported that a combination of the presence of a slit-like contrast column in the interatrial septum and a contrast jet in the septum

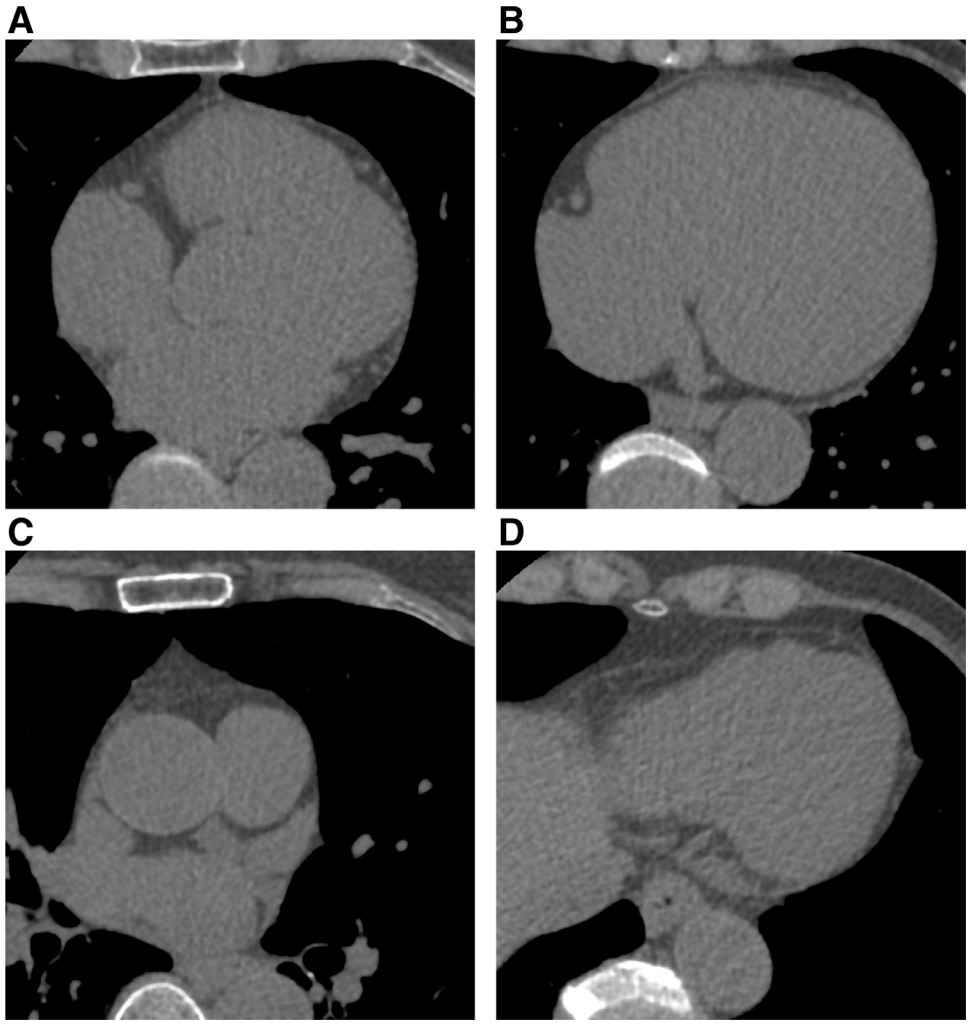

Fig. 3 – Subsequent nonenhanced ECG-gated CT acquired after monitoring with her Trendelenburg position revealed no residual air bubbles. Slice positions of images (A-D) are correspondings to those in Fig. 1.

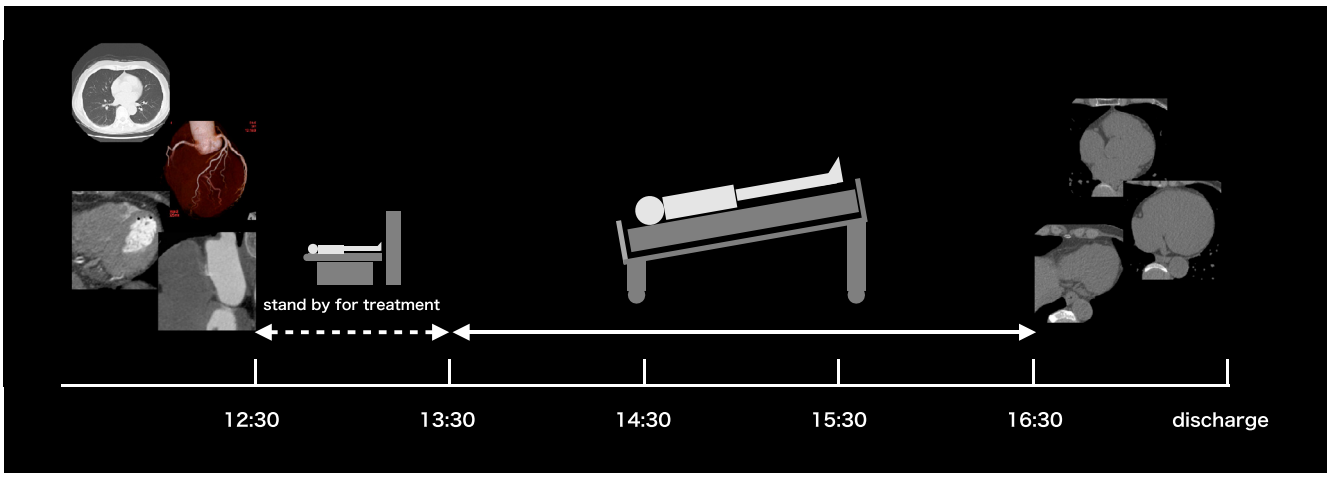

Fig. 4 – Immediately after the examination, air bubbles were found in the left ventricle and medical staffs were called. She was monitored with her spine position on the CT table for 1 hour until discussion about treatment strategy reached consensus. She was monitored for another 3 hours on an outpatient bed with her Trendelenburg position. Then a follow-up nonenhanced ECG-gated CT was imaged, demonstrating no remaining air bubbles in the left ventricle. No intrapulmonary shunt such as pulmonary arteriovenous fistula was found on the initial CT. Finally, she was discharged with no symptom.

Table 1 – Symptoms that may indicate venous air embolism during power contrast injection.

Cardiopulmonary	Neurologic
Gasp	Focal paralysis
Cough	Seizures
Acute shortness of breath	Loss of consciousness
Tachypnea	Altered mental status
Chest pain/unilateral chest pain	Coma
Chest pressure	Loss of sensation in an extremity
Pulmonary edema	Vertigo
Bronchospasm	Blindness
Crepitus	
Hypercapnia or Hypocapnia	**Other**
Cyanosis	Sense of impending death
Hypoxemia	Nausea and vomiting
Hypotension	
Hypercarbia	
Increased central venous or pulmonary artery pressure	
Sinus tachycardia/sinus bradycardia ischemic changes on EKG	
Nonspecific ST segment and T wave changes	
Cardiac conduction disturbance	
Extreme venous congestion	
Acute cor pulmonale	
"Mill-wheel" murmur—if there is a large air embolus in the right ventricle	

From the Pennsylvania Patient Safety Authority [13].

on coronary CT angiography is indicative of a patent foramen ovale [9,10].

In the present case, the patient was asymptomatic. However, since a paradoxical air embolism that brings air bubbles into the left ventricle may lead to serious consequences, more careful handling of the intravenous route is essential in order to avoid an inadvertent, but potentially fatal, paradoxical air embolism. The Pennsylvania Patient Safety Authority has summarized several clinical reports [4,7,8,11,12] to list the symptoms of complications caused by iatrogenic air bubbles associated with the use of intravenous contrast medium (Table 1) [13]. Lee et al proposed that radiologists performing coronary CT angiography should ensure rapid detection of the presence of a paradoxical air embolism so that the attending physician can place the patient in the Trendelenburg position (ie, with the patient's head lower than the feet) and, if required, perform hyperbaric oxygen therapy without delay [14]. In the present case, the physician confirmed that air bubbles in the heart disappeared without clinical symptoms, and we believe the patient returned home safely without special clinical treatment because we followed the proposal of keeping her head lower than her feet.

To the best of our knowledge, there have been no reports regarding a recommendation time interval for placing the patient in Trendelenburg. Lee et al reported that the patient was kept in the Trendelenburg position for 24 hours, and finally, was uneventfully discharged [14]. However, they did show any reason for 24 hours monitoring. In our case, after 3 hours in the Trendelenburg position, we confirmed no residual air bubbles in the left ventricle on the nonenhanced ECG-gated CT. Since no symptom occurred, she was permitted to discharge.

Quality and safety have prime importance in CT examinations; special attention should therefore be given to avoid air in the tubing system between the intravenous catheter and power injector to ensure no air is introduced into the blood circulation.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.radcr.2019.03.017.

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