Transthoracic Echocardiography–Assisted Identification of Coronary Air Embolism During Coronary Angiography

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INTRODUCTION

Air embolism is a rare and potentially catastrophic event that most commonly occurs by an iatrogenic or traumatic mechanism. Air embolism requires a portal of entry and pressure gradient for air to be introduced into an arterial or venous circulation. The presenting symptoms of air embolism can vary depending on the volume of air that becomes embolized, the arterial or venous circulation it enters, and the end organs that are affected. The onset of symptoms is typically rapid.

This report presents a case of a coronary artery air embolism (CAE) that occurred during coronary angiography and demonstrates the utility of transthoracic echocardiography (TTE) in determining the clinical and angiographic parameters of diagnosis, while also discussing the fundamental management strategy.

CASE PRESENTATION

A 55-year-old man presented to an outpatient cardiology clinic for evaluation of ongoing chest pain. The patient was referred for invasive coronary physiology testing to assess for vascular dysfunction.

At the beginning of the procedure, the left anterior descending coronary artery (LAD) was engaged with a JL4 guide and contrast media was injected. Almost immediately, the patient experienced the abrupt onset of severe chest pain followed by ventricular asystole. Cardiopulmonary resuscitation (CPR) ensued with periods of pulseless electrical activity and ventricular fibrillation. Epinephrine was administered, and the patient received 1 defibrillation. After 10 minutes of CPR, return of spontaneous circulation (ROSC) was achieved. The interventional team was concerned about CAE as the inciting event, but attempts at intracoronary aspiration were unsuccessful during CPR. Immediately after sustained ROSC, angiography of the LAD demonstrated sluggish flow, but no CAE was identified by fluoroscopy (Figure 1, Video 1). Emergent echocardiography was performed, which demonstrated a new decrement in left ventricular ejection fraction (now 30%-35% from 66% 2 days prior), akinesis of anterior and septal walls from base to apex, echogenicity of the myocardium in the anterior and anteroseptal walls, and concomitant bright reverberation artifact in a "comet-tail" pattern (Videos 2 and 3). This echogenicity or "speckling" of the myocardium is characteristic of intramyocardial air (Figures 2 and 3). Furthermore, the defined vascular distribution of the echogenicity corresponds to the LAD and therefore supports an air embolism during coronary injection as the etiology of the cardiac arrest.

The patient was transferred to the cardiac intensive care unit where they were placed on a norepinephrine infusion for low mean arterial pressures and 100% FiO_2 by nonrebreather mask. Electrocardiogram was performed and showed normal sinus rhythm without significant ischemic changes. The patient's clinical condition improved over 24 hours, and they were liberated from vasopressor support. Repeat TTE demonstrated improvement in left ventricular ejection fraction (50%) and resolution of the regional wall motion abnormalities in the LAD vascular territory (Figures 4 and 5, Videos 3 and 4). There were no subsequent rhythm disturbances during the hospitalization; the patient was initiated on metoprolol and discharged home 2 days after admission.

DISCUSSION

This case is a significant addition to the existing literature as it demonstrates the most severe manifestation of CAE, cardiac arrest, and illustrates the value in TTE-assisted identification. The clinical presentation of CAE exists on a spectrum from asymptomatic to the development of chest pain, circulatory failure, or, in the most severe case, cardiac arrest. Coronary artery air embolism during coronary angiography remains an uncommon event, with a proposed incidence of 0.1% to 0.3%.[1,2] As such, there is a paucity of data on the topic. Because of the invasive nature of coronary angiography, there are many mechanisms by which air embolism can occur: through the introduction or withdrawal of catheters and guidewires, defective manifold systems/preparation, and incorrectly flushed syringes or catheters. Moreover, it has been reported that CAE can be fatal with as little as 0.5 to 1.0 mL of air being introduced into the coronary circulation.[3] Case reports implicate the LAD as the most commonly affected coronary artery in these circumstances,[2] although the right coronary artery has a more anterior ostial position, which is more anatomically susceptible to CAE following cardiopulmonary bypass. The LAD distribution happens to be the same afflicted territory as in our patient.

The typical diagnosis of CAE is by fluoroscopic evaluation during coronary angiography where the air bubble can be directly visualized. As such, TTE has not been previously reported as a mode of detection in cases of CAE specifically, but it has been a well-reported diagnostic tool in many other cases of air embolism.[4] The mechanism involved

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Keywords: Air embolism, Cardiac arrest, Coronary artery embolism

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VIDEO HIGHLIGHTS

Video 1: Coronary angiography (following cardiac arrest) left anterior oblique cranial view demonstrates Thrombolysis in Myocardial Infarction 3 flow without residual CAE in the LAD.
Video 2: Two-dimensional TTE parasternal long-axis view demonstrates hyperechogenicity or speckling of the mid-distal anteroseptum due to the presence of intramyocardial air. The anteroseptum also displays decreased systolic thickening characteristic of myocardial ischemia. Notably, the distal anteroseptum is the most echo bright as it has the largest concentration of intramyocardial air, which causes reverberation artifact of the far-field in this region.
Video 3: Two-dimensional TTE, parasternal short-axis view, performed in the setting of acute coronary angiography demonstrates anterior and anteroseptal regional hypokinesis and hyperechoic (echo bright) tissue characterization due to the presence of intramyocardial air *(left)* compared with normal motion and tissue characterization *(right)* obtained as a serial study 2 days later.
Video 4: Two-dimensional TTE, apical 4-chamber view, obtained 2 days after the cardiac arrest demonstrates improvement in the apical septum intramyocardial air and regional left ventricular systolic function.

View the video content online at www.cvcasejournal.com.

with TTE diagnosis of CAE is explained by the physics of sound waves and the interaction with soft tissues of varying density. Echogenicity is based on the acoustic impedance mismatch between tissues, where high acoustic impedance leads to echogenic (brighter) images and vice versa. Thus, CAE is composed of bubbles in a high-pressure system, which increases the density, resulting in a high-impedance mismatch between the bubble and myocardial tissue. This mechanism of myocardial enhancement has been previously detailed and is intentionally utilized in patients with hypertrophic cardiomyopathy who undergo alcohol ablation of the septal branch. Moreover, intraprocedural TTE is performed with echocardiographic contrast to highlight the territory of the septal branch prior to the ablation and shows a similar appearance to that of air embolsim.[5] Collectively, this explains the reason for the echogenic appearance of CAE on TTE. In this case report, the myocardial air is visualized within the anterior and anteroseptal walls at the mid-distal segments (Figures 2 and 3, Videos 2 and 3).

In the circumstance of CAE, management involves 2 core principles: (1) to increase the nitrogen gas diffusion from the air embolism into the plasma and (2) to push the embolism to as distal in the coronary circulation as possible to encourage formation of smaller bubbles and reduce the potential area of myocardial ischemia.[6] Clinically, this management strategy is achieved by maximizing coronary perfusion pressure through augmentation of the systemic mean arterial pressure with vasopressor therapy. In addition, oxygenation is optimized via hyperbaric oxygen therapy or by providing 100% FiO_2 using noninvasive or invasive ventilation. For larger-volume CAE during angiography, using invasive thrombectomy catheter–guided aspiration or over-the-wire balloon catheters has been suggested.[6-8]

CONCLUSION

Coronary artery air embolism remains a rare phenomenon with a high risk of morbidity and mortality. Echocardiography is an excellent imaging modality for the detection of intramyocardial air and has a complementary role to clinical exam and angiographic findings in suspected or confirmed cases of CAE.

CONSENT STATEMENT

Complete written informed consent was obtained from the patient (or appropriate parent, guardian, or power of attorney) for the publication of this study and accompanying images.

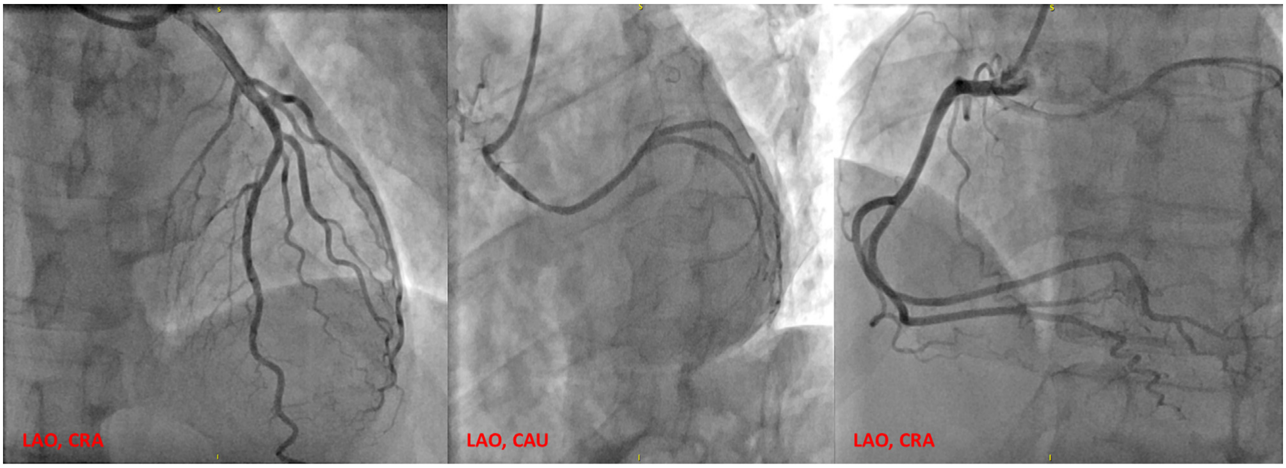

Figure 1 Invasive coronary angiography (following cardiac arrest and CPR) demonstrates nonobstructive coronary arteries. There is a single left-sided coronary vessel (*left*) representing the LAD, with streaming of the contrast seen proximally; an anomalous left circumflex coronary artery that arises from the right coronary cusp (*middle*) and is widely patent; and a normal right coronary artery (*right*). *CAU*, Caudal; *CRA*, cranial; *LAO*, left anterior oblique.

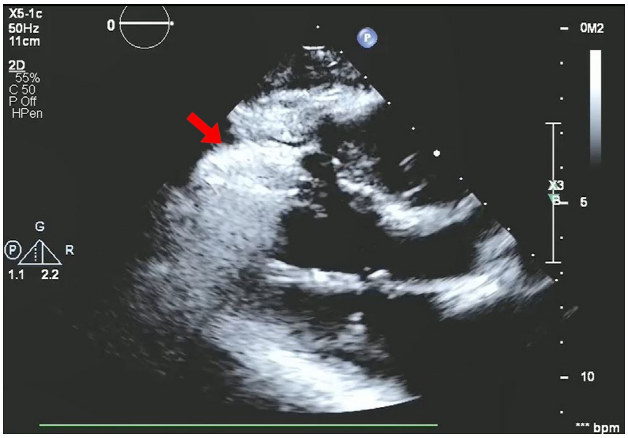

Figure 2 Two-dimensional TTE parasternal long-axis view (obtained soon after coronary angiography) demonstrates the characteristic echogenic appearance (*arrow*) with reverberation artifact obscuring the far-field in a comet-tail fashion from the CAE.

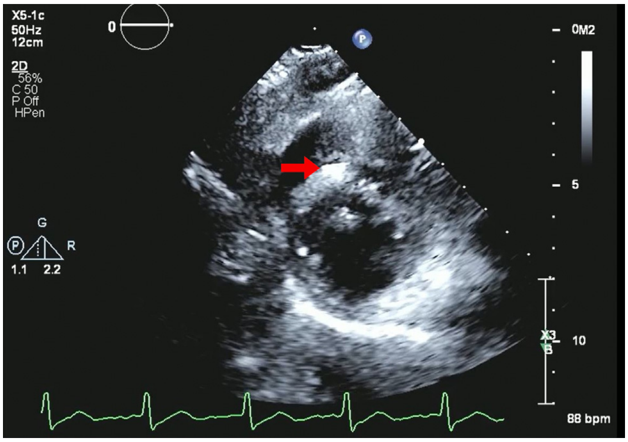

Figure 3 Two-dimensional TTE parasternal short-axis view, mid–left ventricle, demonstrates an echogenic focus (*arrow*) within the anteroseptal segment suggestive of intramyocardial air.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

FUNDING STATEMENT

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

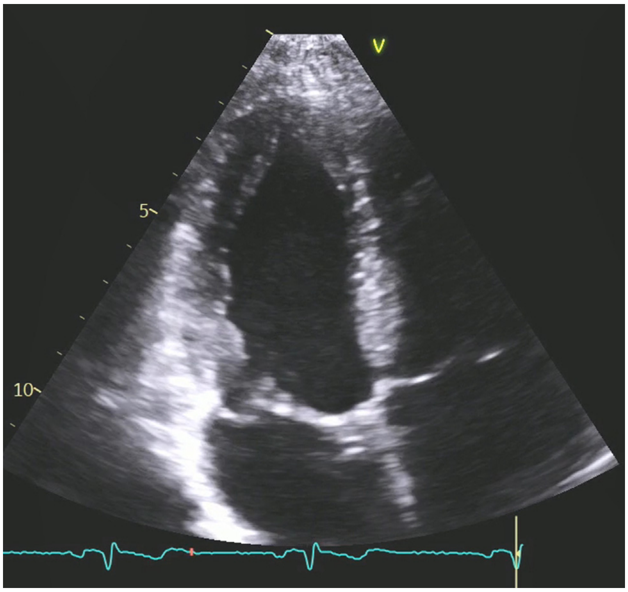

Figure 4 Two-dimensional TTE apical 4-chamber view, diastolic phase, obtained 2 days after the cardiac arrest demonstrates improvement in the intramyocardial air as evidenced by resolution of the previously seen echogenic areas.

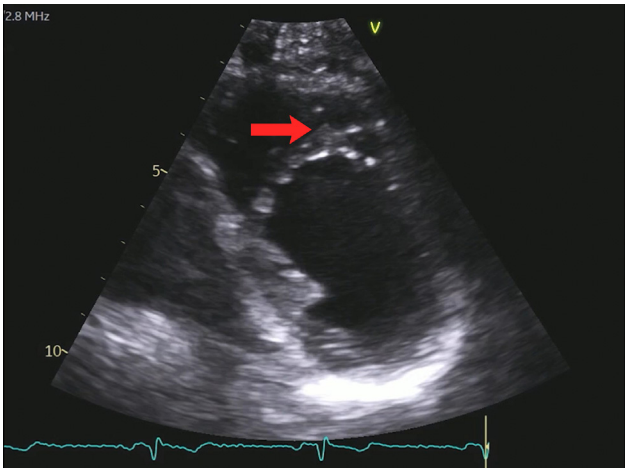

Figure 5 Two-dimensional TTE parasternal short-axis, mid–left ventricle view, diastolic phase, obtained 2 days after the cardiac arrest demonstrates resolution of the echogenic focus previously seen within the anteroseptal segment (*arrow*).

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SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.case.2022.12.013.

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