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INTERMEDIATE

CASE REPORT: CLINICAL CASE

Massive Air Embolism During Atrial Fibrillation Ablation

Averting Disaster in a Time of Crisis

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ABSTRACT

A 62-year-old male with symptomatic persistent atrial fibrillation underwent radiofrequency catheter ablation. During exchange of the saline irrigation bag, the patient developed sudden hypotension and bradycardia and was found to have a massive air embolism. Air was successfully aspirated with catheters, and the patient did not suffer any permanent sequelae. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2021;3:47–52) © 2021 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

A 62-year-old male patient with hypertension received a diagnosis of persistent atrial fibrillation (AF) after developing dyspnea on exertion. He was started on apixaban and metoprolol. He underwent 2 electrical cardioversions but only briefly maintained sinus rhythm. He was reluctant to take antiarrhythmic medications and was referred for catheter ablation. Pre-procedural cardiac magnetic resonance imaging showed mildly enlarged left atrium with normal cardiac function.

LEARNING OBJECTIVES

- To be able to make a differential diagnosis for sudden hypotension and bradycardia during cardiac catheter ablation for atrial fibrillation.
- To identify the causes of air embolism and the clinical manifestation of air embolism.
- To be able to rapidly formulate a treatment plan for massive air embolism.

On the day of the ablation procedure, the patient presented in AF with average heart rate of 65 beats/min. Following induction of general anesthesia, transesophageal echocardiography confirmed no left atrial appendage (LAA) thrombus, bilateral femoral venous access (two 8-F sheaths in the right femoral vein exchanged for long sheaths positioned in the left atrium (9-F and 7-F sheaths in the left femoral vein) was obtained. A 5-F sheath was placed in the right femoral artery. Heparin was given (90 U/kg for a total of 8,000 U, followed by 1,000 U/h drip) to maintain activated clotting time 300 to 350 ms. Double transseptal punctures using a Brockenborough-1 needle (St. Jude Medical, St. Paul, Minnesota) were performed, using intracardiac echocardiographic and fluoroscopic guidance, with confirmation of left atrial positioning by visualization of contrast injection and pressure tracing. Both long sheaths (Agilis and SL-0,

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ABBREVIATIONS AND ACRONYMS

AF = atrial fibrillation

LAA = left atrial appendage

LV = left ventricle

RCA = right coronary artery

St. Jude Medical) were continuously irrigated with heparinized saline infused at 180 ml/h. Through the long sheaths, a circular mapping catheter (Optima, St. Jude Medical) and an irrigated contact force-sensing radiofrequency ablation catheter (Tacticath, St. Jude Medical) were advanced into the left atrium.

Circumferential ablation was performed at 25 to 35 W, a temperature cutoff of 42°C, a goal contact force of 10 to 20 g, and a minimal force time integral of 400 g-s.

After 58 ablation lesions, the ablation catheter saline irrigation bag was empty, and the irrigation pump alerted to the presence of air within the tubing; a new saline bag was attached. A stopcock was opened to flush the system, and the priming function was resumed. Shortly afterward, the patient suddenly became hypotensive and bradycardic.

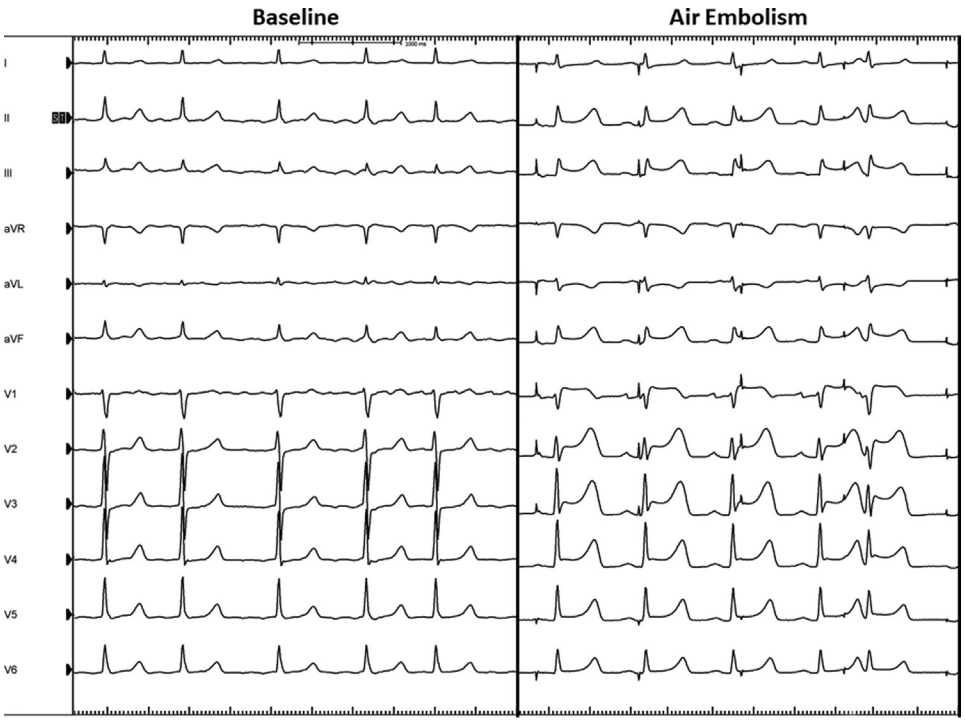
MEDICAL HISTORY

The patient had a history of hypertension and persistent AF.

DIFFERENTIAL DIAGNOSIS

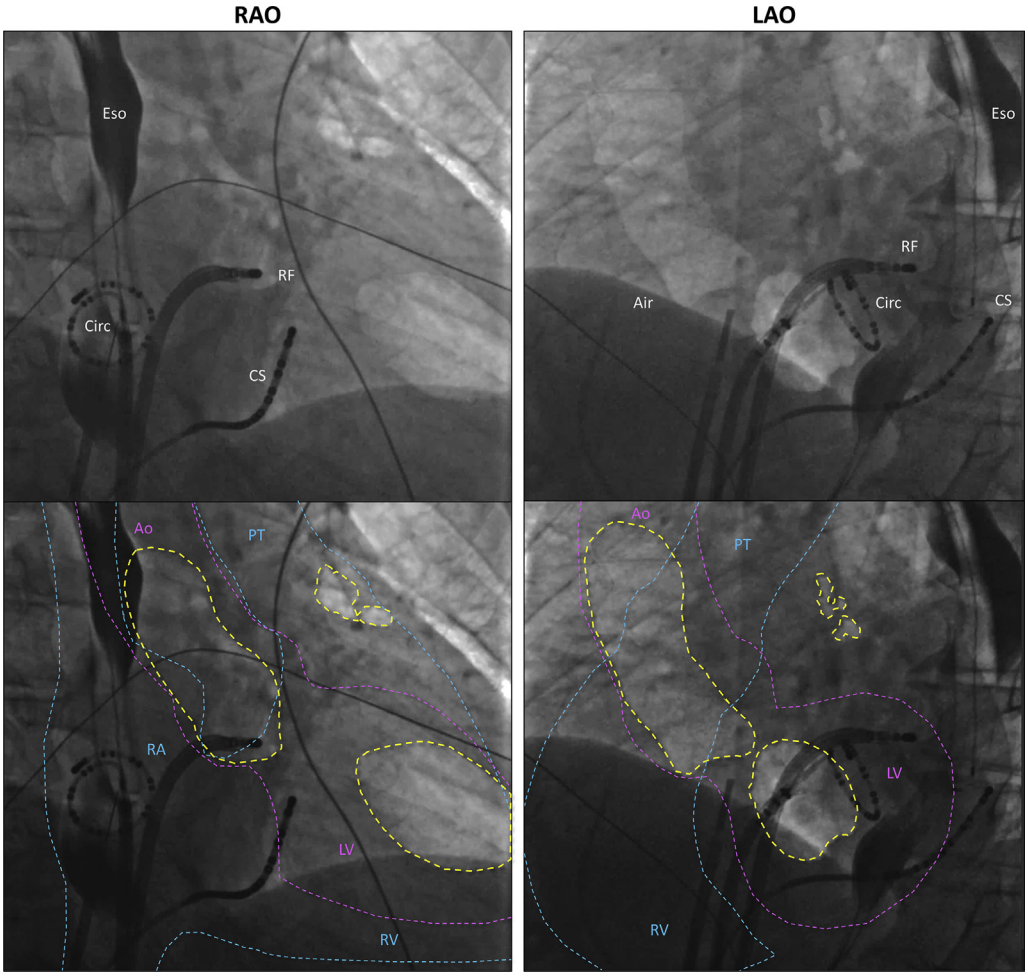
The differential diagnosis for sudden hypotension and bradycardia during AF ablation procedure included an exaggerated vagal response to ablation of a ganglionated plexus near the pulmonary vein; pericardial effusion from perforation during transseptal access or ablation; or air/thromboembolism entering the right coronary artery (RCA). Anaphylactic reactions to

FIGURE 1 Baseline Electrocardiogram Versus Electrocardiogram During Air Embolism



Baseline 12-lead electrocardiogram at the start of the ablation procedure in atrial fibrillation shows normal QRS complex and ST-segments. Following the occurrence of an air embolism, there is marked ST-segment elevation in the right precordial and inferior leads (leads III > II), suggesting a right ventricular and inferior left ventricular injury pattern. Atrial pacing was performed, given initial sinus bradycardia.

FIGURE 2 **Massive Air Embolism in the Left Ventricular Apex and Ascending Aorta**



RAO and LAO views show an area of radiolucency caused by air in the left atrial appendage, left ventricular apex, and ascending aorta, as denoted by the **dotted yellow line**. Ao = aorta; Circ = circular mapping catheter; CS = coronary sinus catheter; Eso = esophagus (with barium); ICE = intracardiac echocardiogram catheter; LAO = left anterior oblique; LV = left ventricle; PT = pulmonary trunk; RA = right atrium; RAO = right anterior oblique; RF = radiofrequency ablation catheter; RV = right ventricle.

contrast or other medications, including anesthetic agents, are also on the differential.

INVESTIGATIONS

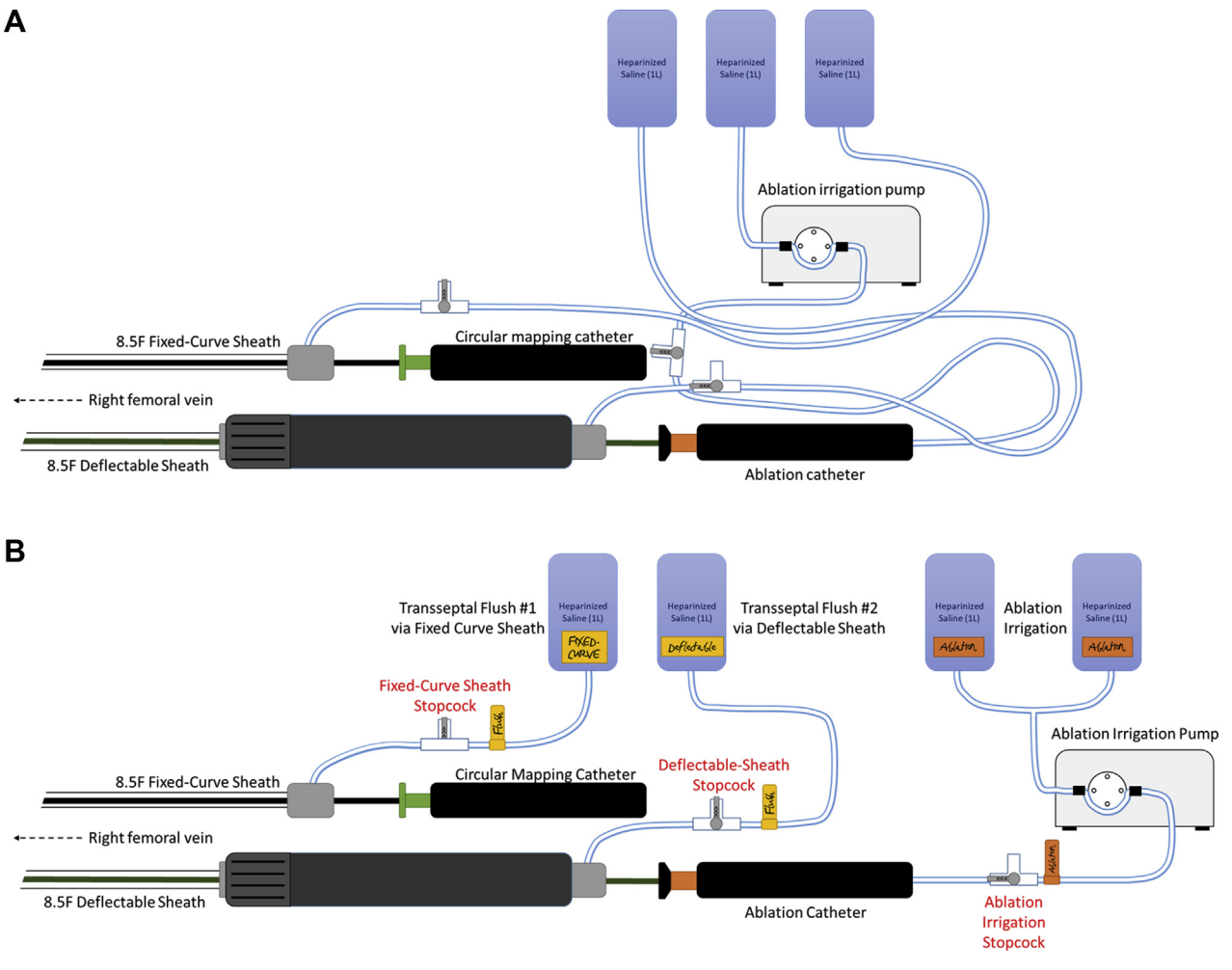
Electrocardiography showed ST-segment elevation in the right precordial and inferior leads (**Figure 1**). Fluoroscopy showed a large amount of air in the LAA, left ventricular (LV) apex, and aortic root (**Figure 2**, Video 1). Intracardiac echocardiography showed no pericardial effusion. Given the timing of the patient's sudden deterioration, air embolism was clearly the cause. Subsequently, it was found that the stopcock leading to the Agilis sheath transseptal flush had been closed to the patient, whereas the stopcock on the ablation catheter remained opened to the patient (**Figure 3A**); hence, air in the irrigation line was flushed into the left heart.

The patient's pupils were also noted to be asymmetrical (6 mm on the left, 2 mm on the right) but reactive to light bilaterally.

MANAGEMENT

A 5-F Judkins Left (JL4) catheter (Merit Medical OEM, South Jordan, Utah) was advanced into the ascending aorta, and air was aspirated (**Figure 4A**). The ablation catheter was replaced sequentially with

FIGURE 3 Irrigation Line Schematic



Sheaths and catheters in the left atrium are shown through a transseptal approach. **(A)** The root cause of air embolism. Multiple unlabeled, tangled irrigation lines made it easy to mistakenly close the deflectable sheath (Agilis) stopcock, leaving the ablation irrigation line stopcock open during the priming function. **(B)** An ideal setup with clearly labeled lines and 2 saline bags for ablation irrigation.

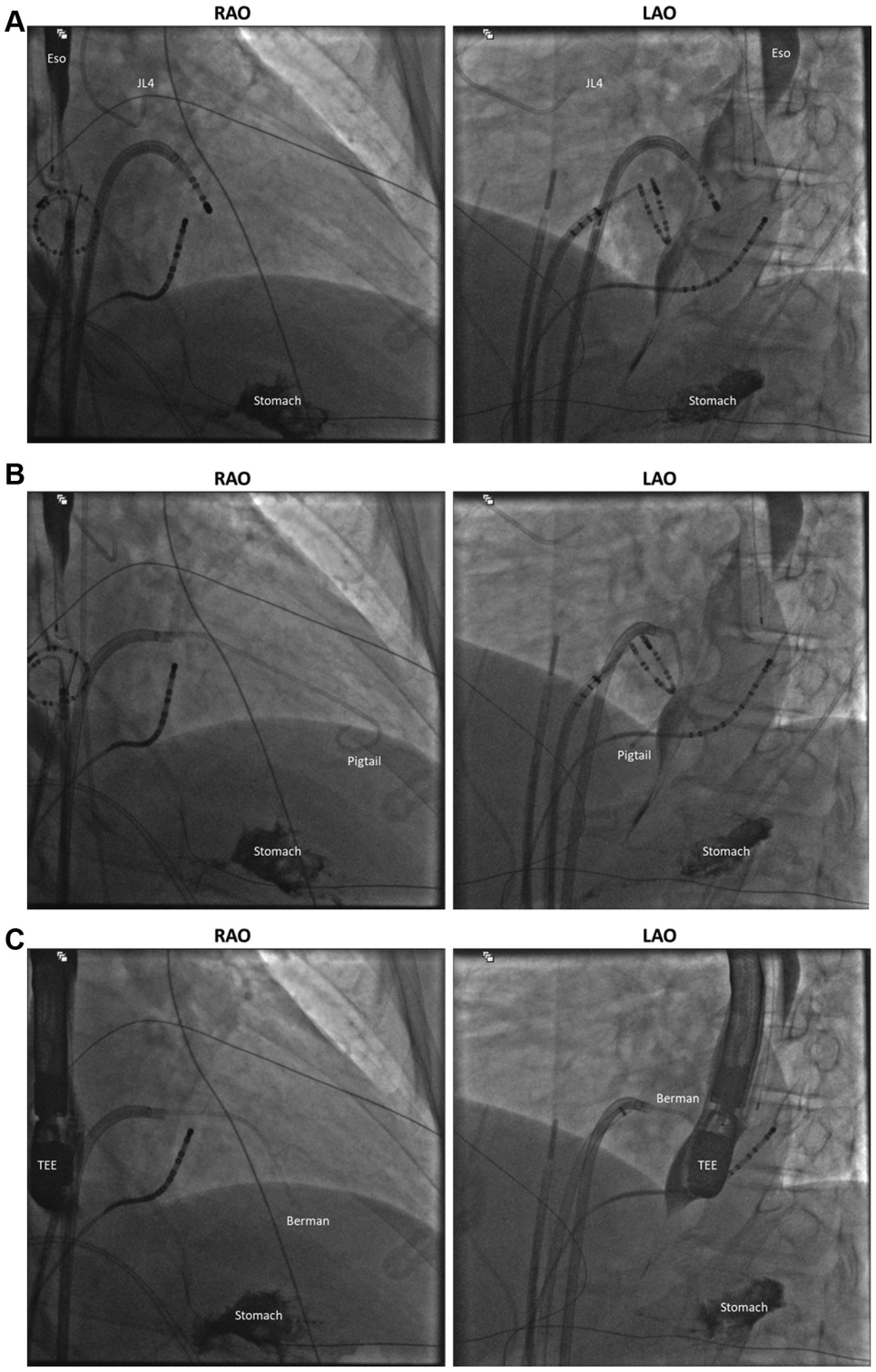
a 5-F pigtail (**Figure 4B**, Video 2) and then a 7-F Berman angiographic catheter (Teleflex Inc, Morristown, North Carolina). These catheters were advanced into the LAA and LV apex using the transseptal approach, and aspiration was performed until there was no further air visualized on fluoroscopy and transesophageal echocardiography (**Figure 4C**). Coronary angiography showed no air in the coronary arteries. All ST-segment elevations, as shown on electrocardiography, had resolved after approximately 15 min. Hyperbaric oxygen therapy was considered, but following cerebral angiography, no air was shown in any of the cerebral vessels, so it was decided to wake the patient up from anesthesia.

No further ablation was performed. Protamine was given, and all sheaths and catheters were removed. His neurologic examination results upon awakening was normal. Transthoracic echocardiography performed the following day showed normal LV ejection fraction and wall motion. He had no procedure-related sequalae at 1-month follow-up.

DISCUSSION

Air embolism is a well-known but infrequent complication of cardiac catheterization procedures. It generally presents as transient (average: 5 min) ST-segment elevations in the inferior leads with

FIGURE 4 **Aspiration of Air From the LV and Ascending Aorta**



(A) Successful aspiration of air from the ascending aorta with a 5-F JL4 catheter. **(B)** A 5-F pigtail catheter advanced into the LV apex to aspirate air. **(C)** The final image after the use of a Berman catheter in the LV apex showsall air successfully aspirated. LV = left ventricle; TEE = transesophageal echocardiogram.

simultaneous bradycardia and hypotension due to RCA occlusion. It is safe to proceed with the procedure after complete resolution (1).

Rarely, however, massive air embolism can result in severe hemodynamic alterations and even cardiopulmonary arrest due to complete RCA occlusion or obstruction to blood flow. Maintaining the patient in a supine or Trendelenburg position is paramount to avoid cerebral air embolism, as air will accumulate in the anterior cardiac structures. Aspiration of air directly from the RCA has previously been described by Ahmad et al. (2). Kuwahara et al. (3) reported that forceful injection of contrast or saline into the RCA could also fragment large occlusive air bubbles. Kuwahara et al. (3) also described aspiration of air from the LAA. In the present case, it was shown that massive air embolism in the LAA, LV, and aorta can be successfully aspirated with catheters.

Careful technique to avoid air embolism is crucial in all left-sided cardiac catheterization procedures. However, unintended equipment failures such as damage to the sheath diaphragm (4) or entrapment of air from deep breaths and negative intrathoracic pressures during insertion of catheters (3) can still occur. The CoolPoint (St. Jude Medical) irrigation system has 2 bubble sensors which immediately shut off irrigation and ablation if air bubbles are found within the tubing. However, during the priming function, the bubble sensors are switched off. Human error (i.e., closing the wrong stopcock) was the root cause of the present complication. Avoiding such complications requires recognition of this potential complication, and protocols requiring multiple laboratory staff to confirm correct procedure when flushing an irrigated catheter situated in the body. Maintaining 2 saline bags for ablation catheter irrigation, protocols for regular checks on remaining bag volume, and color-coding tubing flushing into the left heart can also help.

With rapid recognition and prompt treatment, massive air embolisms can be managed successfully with no permanent sequelae.

FOLLOW-UP

The patient underwent event monitoring at 3- and 6-months post-ablation, both of which showed sinus rhythm and no arrhythmias.

CONCLUSIONS

This paper describes a case of massive air embolism that occurred during an AF ablation procedure due to inadvertent flushing of air through the ablation catheter irrigation line into the left heart. Rapid aspiration of air from the ascending aorta and LV apex was performed. The patient did not experience any permanent sequelae. Catheterization laboratory protocols to avoid air embolism during saline irrigation bag exchanges are necessary to avoid this potentially catastrophic complication.

AUTHOR DISCLOSURES

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KEY WORDS air embolism, atrial fibrillation, catheter ablation

APPENDIX For supplemental videos, please see the online version of this paper.