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CASE REPORT

INTERMEDIATE

CLINICAL CASE

Pulmonary Vein Perforation and Life-Threatening Hemoptysis During Cryoballoon Ablation for Persistent Atrial Fibrillation

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ABSTRACT

Cryoballoon ablation is an effective method for pulmonary vein isolation for atrial fibrillation; however, unexpected complications may occur while performing the ablation procedure. We report an extremely rare case of pulmonary vein perforation with hemoptysis that required emergency lobectomy caused by injury from a circular mapping catheter. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2022;4:418–423) © 2022 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/).

HISTORY OF PRESENTATION

A 75-year-old man with symptomatic persistent atrial fibrillation underwent cryoballoon ablation (CBA). On physical examination, the patient's height was 177 cm and his weight was 73 kg. Electrocardiography revealed atrial fibrillation, with a heart rate of 76 beats/min and a systolic blood pressure of 110 mm Hg on admission. Anticoagulant therapy (5 mg apixaban twice daily) was temporarily switched to 150 mg dabigatran twice daily 1 day before the procedure. After the vein was punctured, a heparin bolus (100 U/kg) was administered, followed by continuous infusion of heparin. An activated clotting time between 350 and 400 seconds was maintained after transseptal puncture. Propofol was used for sedation, and intraoperative respiratory control was achieved using the i-gel supraglottic airway device with tracheal intubation. Pulmonary vein isolation was performed using a 28-mm fourth-generation cryoballoon catheter (Arctic Front Advance; Medtronic, Inc). A dedicated steerable 15-F sheath (FlexCath Advance; Medtronic, Inc) was introduced into the left atrium over the wire along with the cryoballoon catheter. The left superior

LEARNING OBJECTIVES

- To recognize that pulmonary vein perforation, an extremely rare complication of cryoballoon ablation, can develop into life-threatening hemoptysis and require emergency surgery.
- To understand the importance of careful handling of circular mapping catheters in a small and quickly bifurcating pulmonary vein for avoiding complications such as pulmonary vein perforation.
- To examine the anatomy of the pulmonary veins by preprocedure CT and understand its importance in selecting the ablation strategy.

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pulmonary vein and left inferior pulmonary vein were successfully isolated by freezing for 180 seconds. To prevent phrenic nerve injury, the diaphragm was paced by an electrode in the superior vena cava while monitoring the compound motor action potential. Subsequently, a newly developed 20-mm circular mapping catheter (Achieve; Medtronic, Inc) was inserted into the proximal right inferior pulmonary vein (RIPV), and contrast injection revealed complete cryoballoon occlusion of the RIPV. However, the contrast medium showed unnatural accumulation (**Figure 1A,** Video 1) before cryothermal energy application; hence, the circular mapping catheter was removed from the RIPV and reinserted. Then, we injected the contrast medium again to confirm the complete cryoballoon occlusion status.

PAST MEDICAL HISTORY

The patient's medical history was unremarkable for any cardiac disease or cardiothoracic surgeries.

DIFFERENTIAL DIAGNOSIS

Based on the first contrast medium injection for RIPV angiography, pulmonary vein injury and perforation during catheter manipulation or pulmonary vein dissection by the guiding catheter was the primary differential diagnosis.

INVESTIGATIONS

During the second contrast medium infusion into the RIPV with complete cryoballoon occlusion, the angiography revealed unexpected contrast findings in the small upper RIPV branch, and the patient experienced sudden massive hemoptysis (**Figure 1B,** Video 2). Although the patient's blood pressure and heart rate were stable, his oxygen saturation level had decreased.

MANAGEMENT

We decided to remove the supraglottic airway device and perform endotracheal intubation to secure the airway with a single-lumen tube, which was changed to a left-sided double-lumen tube to ensure intraoperative 1-lung ventilation. Furthermore, a bronchial blocker was inserted into the right lower lobe from the bronchial lumen to stop the bleeding (**Figure 2,** Video 3). Idarucizumab and protamine were injected to reverse the anticoagulant effect of dabigatran and to antagonize heparin, respectively. Computed tomography (CT) angiography revealed massive pulmonary hemorrhage and contrast

ABBREVIATIONS AND ACRONYMS

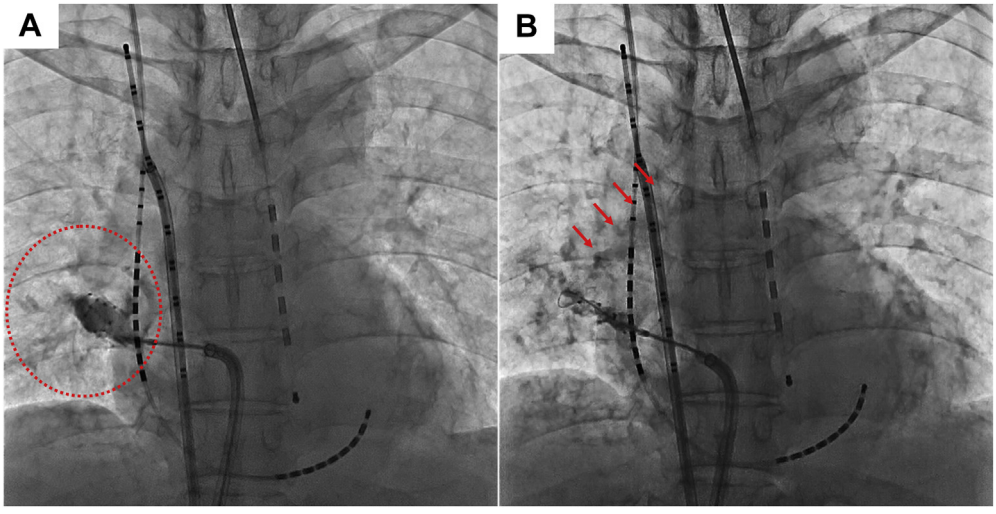
CBA = cryoballoon ablation

CT = computed tomography

POD = postoperative day

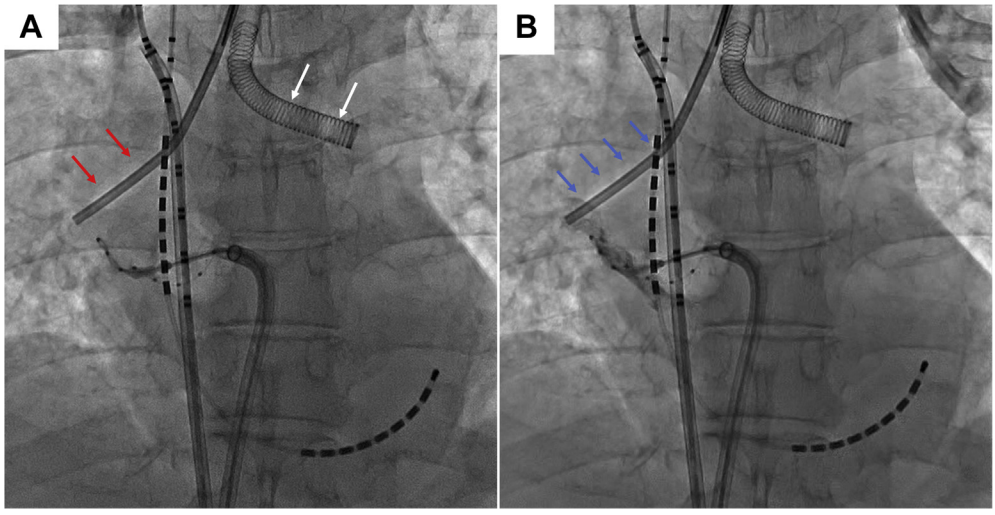
RIPV = right inferior pulmonary vein

FIGURE 1 Right Inferior Pulmonary Vein Angiography



(A) Post-first right inferior pulmonary vein angiography with complete cryoballoon occlusion. The contrast medium showed unnatural accumulation **(red dotted circle). (B)** After insertion of the circular mapping catheter into the right inferior pulmonary vein again, complete occlusion can be observed on the second angiography, and hemoptysis occurred subsequently. The contrast medium regurgitated into the bronchi **(red arrows)**.

FIGURE 2 After Intubation Using a Double-Lumen Tube

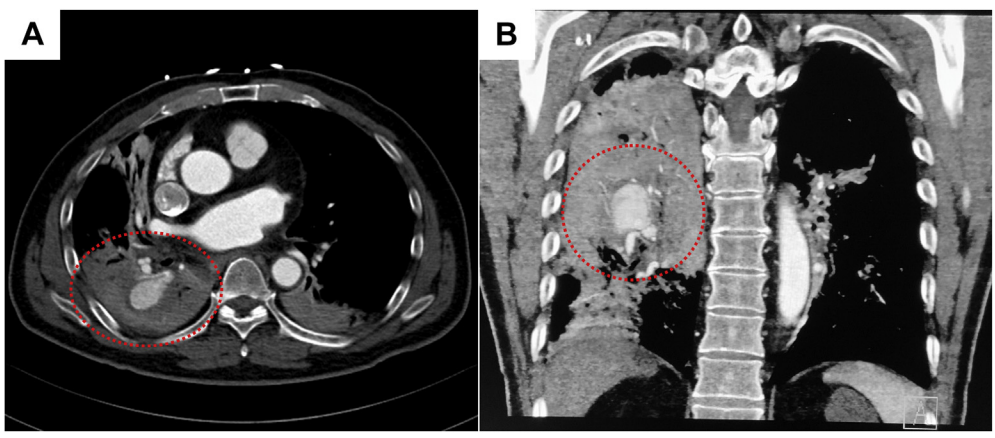


(A) After intubation using a double-lumen tube **(white arrows)** and a bronchial blocker **(red arrows)** to the right lower lobe of the bronchial lumen. **(B)** Contrast medium regurgitation into the lower bronchi stopped caused by bronchial blocker obstruction **(blue arrows)**; however, leakage of the contrast medium into the lung persisted.

medium leakage into the right lower lobe (Figure 3), but there was no air thrombosis. Three-dimensional CT, compared with that before CBA (Figure 4A), showed a perforated small upper RIPV branch (Figure 4B). Endobronchial bleeding was persistent, whereas fresh blood filled the endotracheal tube. The patient underwent urgent thoracoscopic right lower lobectomy 6 hours after catheter ablation. On postoperative day (POD) 1, the patient's respiratory status was stable; amiodarone was initiated to maintain sinus rhythm because pulmonary vein isolation remained incomplete. On POD 4, the chest tube was removed and 5 mg apixaban twice daily was initiated. The patient was discharged on POD 24.

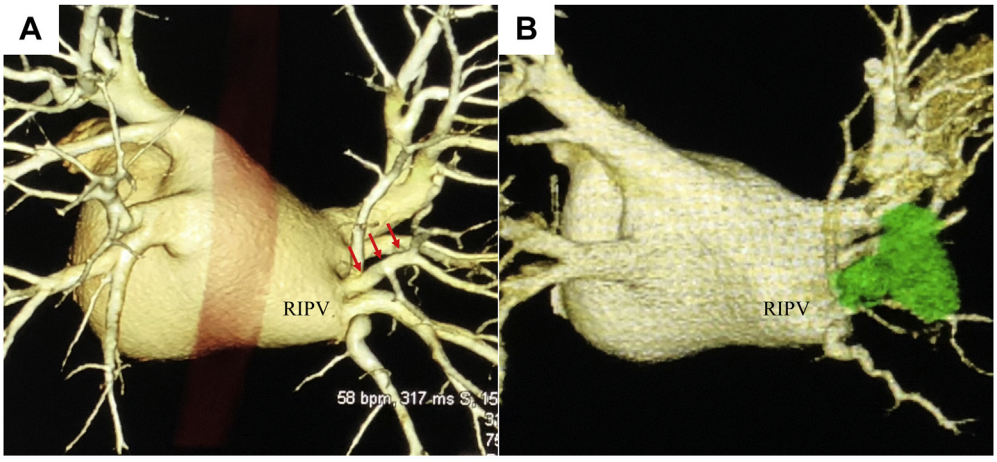
The macroscopic findings of the right lower lobe (Figure 5) revealed a large, intrapulmonary hematoma. Microscopic examination (Figure 6) revealed the upper lumen with the pulmonary vein lumen and

FIGURE 3 Computed Tomography Angiography



Computed tomography angiography shows contrast medium leakage into the right lower lobe within the **red dotted circle**. **(A)** Axial view, **(B)** frontal view.

FIGURE 4 3-Dimensional Computed Tomography



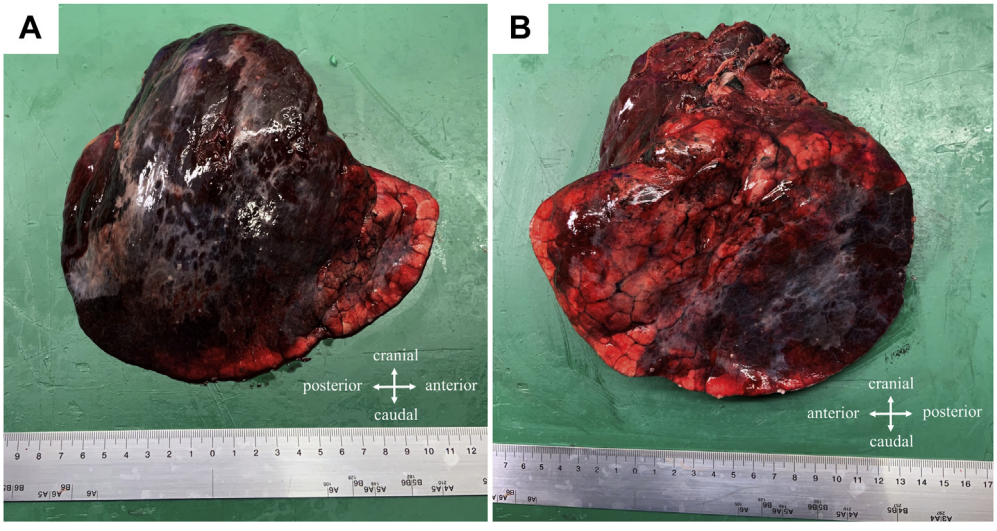
(A) Three-dimensional computed tomography angiography of the pulmonary veins before cryoballoon ablation demonstrates an uncommon right inferior pulmonary vein (RIPV) anatomy that immediately branches into 3 thin branches. **Red arrows** indicate the upper branch. **(B)** Three-dimensional computed tomography angiography of the pulmonary veins after cryoballoon ablation; contrast medium leakage is indicated by the **green area**, and the small upper RIPV branch was injured by the circular mapping catheter.

the lower lumen showing the lung interstitium. A ruptured pulmonary vein wall and pulmonary hemorrhage were observed with no RIPV dissection, suggestive of mechanical injury by the circular mapping catheter, without lodging. A microperforation was confirmed.

DISCUSSION

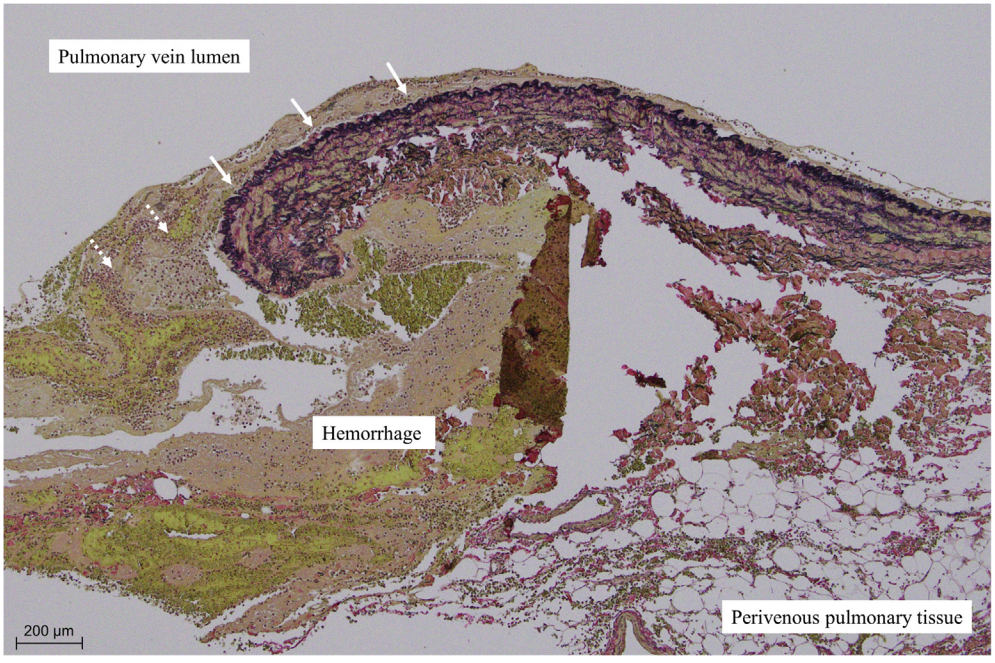
In a prospective nationwide multicenter registry in Japan,[1] an acute complication rate of 2.8% associated with ablation procedures was reported, although cases of pulmonary vein injury or perforation have

FIGURE 5 Right Lower Lobe With Intrapulmonary Hematoma



(A) Right-sided view, **(B)** inside view.

FIGURE 6 Microscopic Image With Elastica van Gieson Staining



Magnification of the right inferior pulmonary vein, which was injured by the circular mapping catheter. This image shows the pulmonary vein wall **(white arrows)** and ruptured pulmonary vein **(white dotted arrows)**. The hemorrhage invaded the perivenous pulmonary tissue.

not been described. Pulmonary vein perforation is a serious complication following CBA, although only a few cases have been reported. No large comprehensive studies have yet been conducted. However, awareness regarding such complications following balloon-guided ablations is necessary.

Bessière et al[2] reported the first case of pulmonary vein hematoma as another complication after CBA in 2013. Subsequently, Fukunaga et al[3] noted left superior pulmonary vein perforation during CBA that was attributed to damage caused by the stiff part of the circular mapping catheter. Yoshizawa et al[4] described the entrapment of the circular mapping catheter in a small branch of the RIPV, which required surgical removal. For our patient, we concluded that the pulmonary vein perforation was caused by the circular mapping catheter, which damaged the small branch of the RIPV. However, unlike the previous report, emergency lobectomy was required to manage the continuous massive hemoptysis in our patient. Therefore, the circular mapping catheter should not be inserted deeply and quickly into a small and bifurcated pulmonary vein. A smaller (15-mm) catheter or the newly developed circular mapping catheter might help in avoiding such severe complications.

For cases of massive hemoptysis caused by pulmonary vein perforation, it is vital to protect the uninjured lung and preserve gaseous exchange. In our patient, we focused on protecting the healthy lung and immediately separating it from the injured lung. Hence, a double-lumen tube was used to protect the healthy lung. Simultaneously, the affected lung needs to be treated. If controlling the hemorrhage is difficult, emergency surgery including lobectomy should be considered.

FOLLOW-UP

The patient reported mild dyspnea in his daily life, but had not experienced palpitation or fainting with arrhythmia. A 24-hour Holter electrocardiography performed at 3 and 9 months after CBA showed normal sinus rhythm and no arrhythmia. Dyspnea

gradually improved with time, and follow-up has been continued in the outpatient clinic.

CONCLUSIONS

Pulmonary vein perforation during CBA for persistent atrial fibrillation can necessitate emergency lobectomy in situations when bleeding control through other methods may be infeasible. To minimize mechanical stress, simple distal rapid pushing and pulling maneuvers of the circular mapping catheter should be avoided, especially in a small branch of the pulmonary vein that can quickly bifurcate. A circular mapping catheter should be handled extremely carefully to avoid such severe complications.

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REFERENCES

1. Kusano K, Yamane T, Inoue K, et al, for the J-AB Registry Investigators. The Japanese Catheter Ablation Registry (J-AB): a prospective nationwide multicenter registry in Japan. Annual report in 2018. *J Arrhythm*. 2020;36:953-961.

2. Bessière F, Chevalier P. Pulmonary vein hematoma after atrial fibrillation cryoablation: a new complication. *Heart Rhythm*. 2013;10:1359.

3. Fukunaga H, Higuchi R, Tanizaki K, Isobe M. Pulmonary vein perforation into bronchi: a rare but life-threatening complication of cryoballoon ablation. *Eur Heart J Case Rep*. 2019;3:ytz022.

4. Yoshizawa R, Owada S, Sawa Y, Deguchi H. Successful removal of a circular mapping catheter which perforated the pulmonary vein during cryoballoon ablation by lateral thoracotomy: a case report. *Eur Heart J Case Rep*. 2020;4:1-5.

KEY WORDS circular mapping catheter, complication, emergency lobectomy, pulmonary vein isolation

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