

Successful removal of a circular mapping catheter which perforated the pulmonary vein during cryoballoon ablation by lateral thoracotomy: a case report

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Background

Serious complications may occur during cryoballoon ablation (CBA). However, pulmonary vein (PV) perforation by a circular mapping catheter and the strategy for removing the catheter remain poorly understood.

Case summary

A 40-year-old male presented with palpitations 2 years ago and was diagnosed with paroxysmal atrial fibrillation 5 months ago. He underwent CBA for paroxysmal atrial fibrillation. After isolation of the left PV, a circular mapping catheter was advanced in the right inferior pulmonary vein (RIPV), and single freeze was performed. After isolation of the PV, the catheter tip was immobile and could not be withdrawn with significant resistance. Computed tomography showed that the catheter tip perforated the posterior basal vein (V10) of the RIPV and remained in the right lower lobe, along with intrapulmonary haemorrhage. The patient underwent surgery via right lateral thoracotomy to remove the catheter. The RIPV was peeled to the periphery to expose the V10. The catheter perforated the vessel wall in the middle of the V10 and entered the pulmonary parenchyma. A microincision on the lung parenchyma covering the surface of the catheter tip was performed, and the circular distal portion of the catheter was cut. The entire catheter (i.e. shaft and proximal portion) was successfully removed from the transeptal catheter.

Discussion

Surgical approach was performed for the management of PV perforation caused by a circular mapping catheter. This case may assist in troubleshooting and problem-solving in case such an event occurs again during procedures in the future.

Keywords

Atrial fibrillation • Cryoballoon ablation • Pulmonary vein isolation • Complication • Case report

Learning points

- Pulmonary vein (PV) perforation by a circular mapping catheter during cryoballoon ablation is a very rare complication.
- Lateral thoracotomy permitted the safe and secure removal of the catheter which perforated the PV, while reducing the risk of fatal bleeding.

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Introduction

Cryoballoon ablation (CBA) has been widely accepted as a treatment of paroxysmal atrial fibrillation.¹ It is established that serious complications (i.e. oesophageal ulcer, atrial oesophageal fistula, bronchial injury, and phrenic nerve injury) occur during CBA.² However, pulmonary vein (PV) perforation by a circular mapping catheter and the strategy for removing the catheter remain poorly understood. Herein, we describe the first application of lateral thoracotomy for the removal of a circular mapping catheter which perforated the PV during CBA.

Timeline

Dates	Events
2017	Awareness of palpitation.
June 2019	Diagnosis of paroxysmal atrial fibrillation.
12 December 2019	Hospitalization.
13 December 2019	Cryoballoon ablation. The circular mapping catheter perforated the right inferior pulmonary vein during the procedure. The catheter was removed by surgery via right lateral thoracotomy.
25 December 2019	Discharge without complications.
8 January 2020	Post-operation follow-up (2 weeks). There were no complications or recurrence of atrial fibrillation.
29 January 2020	Post-operation follow-up (1 month). There were no complications or recurrence of atrial fibrillation.

Case presentation

A 40-year-old man presented with palpitations 2 years ago and was diagnosed with paroxysmal atrial fibrillation 5 months ago. He was receiving anticoagulation treatment with edoxaban.

On admission, the examinations showed that he was haemodynamically stable. Surface 12-lead electrocardiography revealed sinus rhythm. Laboratory investigations revealed no notable findings. Physical examination, chest X-ray, and echocardiography did not yield evidence of clinically overt structural and/or organic heart disease.

Catheter ablation using the CBA system was performed under sedation with dexmedetomidine. A transeptal puncture was performed without any complication, and angiography of the left atrium (LA) showed four independent PVs. Heparin was administered to maintain an activated clotting time >300 s. A 20-mm circular mapping catheter (Achieve™; Medtronic, Minneapolis, MN, USA) and a 28-mm cryoballoon catheter (Arctic Front™; Medtronic) were advanced into the LA via a steerable sheath. Firstly, we targeted the two left PVs with single freeze, under observation of the oesophageal temperature using an internal oesophageal probe. Afterwards, a circular mapping catheter was advanced in the right inferior pulmonary

vein (RIPV), and single freeze was performed along with phrenic nerve capture (Figure 1A). After isolation of the PV, an attempt was made to withdraw the catheter from the PV. However, the catheter tip was immobile and could not be withdrawn with significant resistance. Repeated attempts to withdraw the catheter by rotational traction were not effective (Figure 1B). Computed tomography showed that the catheter tip perforated the posterior basal vein (V10: posterior basal vein) of the RIPV and was stuck in the right lower lobe, along with intrapulmonary haemorrhage (Figure 2A and B). Considering that strong traction could cause major bleeding and breakage of the catheter, surgical removal was performed after obtaining informed consent from the patient.

Surgery was performed via right 7th intercostal lateral thoracotomy. The right lung (mainly S10: posterior basal segment) was congested due to intrapulmonary haemorrhage. The RIPV was peeled to the periphery to expose the posterior basal vein (V10). The catheter perforated the vessel wall in the middle of V10 and entered the pulmonary parenchyma (Figure 3A). The catheter could not be removed even through direct traction. A microincision on the lung parenchyma covering the surface of the catheter tip was performed, and the circular distal portion of the catheter was cut (Figure 3B). The entire catheter (i.e. shaft and proximal portion) was successfully removed from the transeptal catheter, and the V10 was repaired using suture. The removed catheter had a fracture at the junction of the distal portion and the shaft due to repeated traction (Figure 4). After surgery, the patient had an uneventful course without evidence of complications.

Discussion

To the best of our knowledge, this is the first reported application of a surgical approach for the removal of a circular mapping catheter which perforated the PV during CBA.

Firstly, perforation of the PV by a circular mapping catheter during CBA is a very rare complication. The incidence of this complication is unknown, and only a few cases of circular mapping catheter entrapment or perforation of the PV have been reported.^{3–6} This complication may be caused by the distal portion (tip) of the catheter becoming lodged in a small side branch or diverticulum.³ Currently, there is no practical approach described in the literature for managing this situation. In a previous case, the catheter was successfully removed by traction, and conservative treatment of pulmonary haemorrhage was possible.⁵ However, this manoeuvre is associated with a risk of a major haemorrhage. It has also been reported that the catheter may fracture at the junction of the distal portion (soft and pliable) and the shaft (stiff), and at the tip between the straight and circular parts due to repeated traction.^{3,4,6} In this case, a circular mapping catheter perforated a small branch of the PV and remained in the lung parenchyma. Thus, the surgical approach was selected as a safe method for the removal of the catheter to avoid the risk of fracture of the catheter, and the occurrence of a fatal bleeding event requiring an emergency thoracotomy.

Secondly, lateral thoracotomy was performed to remove the catheter which perforated the PV. In a previous case, it was reported that an ablation catheter, which perforated near the ostium of the RIPV, was removed by open-heart surgery.⁷ Unlike

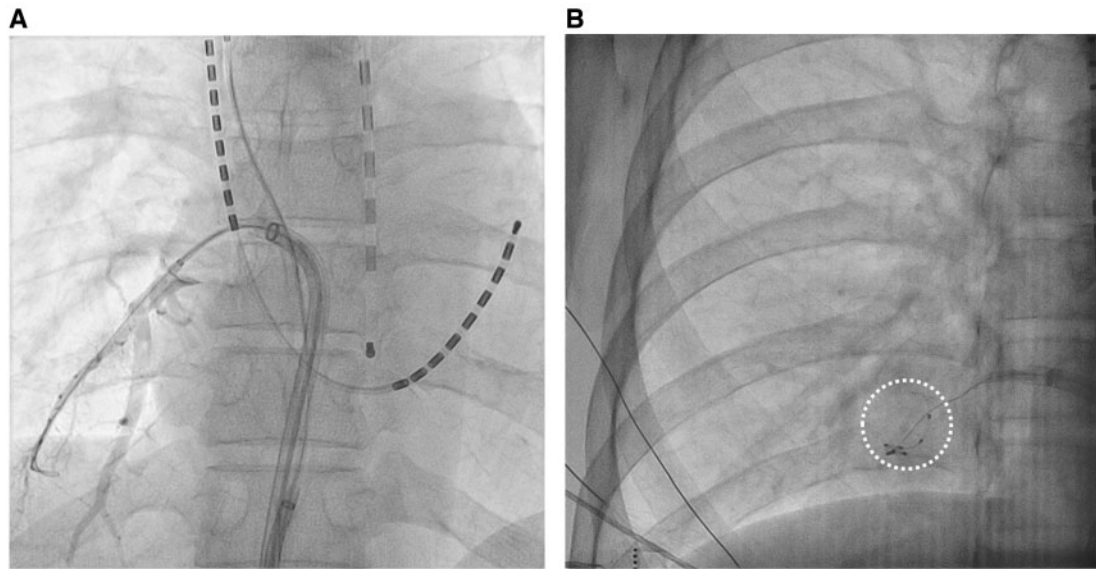


Figure 1 (A) Venogram of the right inferior pulmonary vein during cryoballoon ablation. (B) Fluoroscopic image of the circular mapping catheter pulled to the maximum (circle).

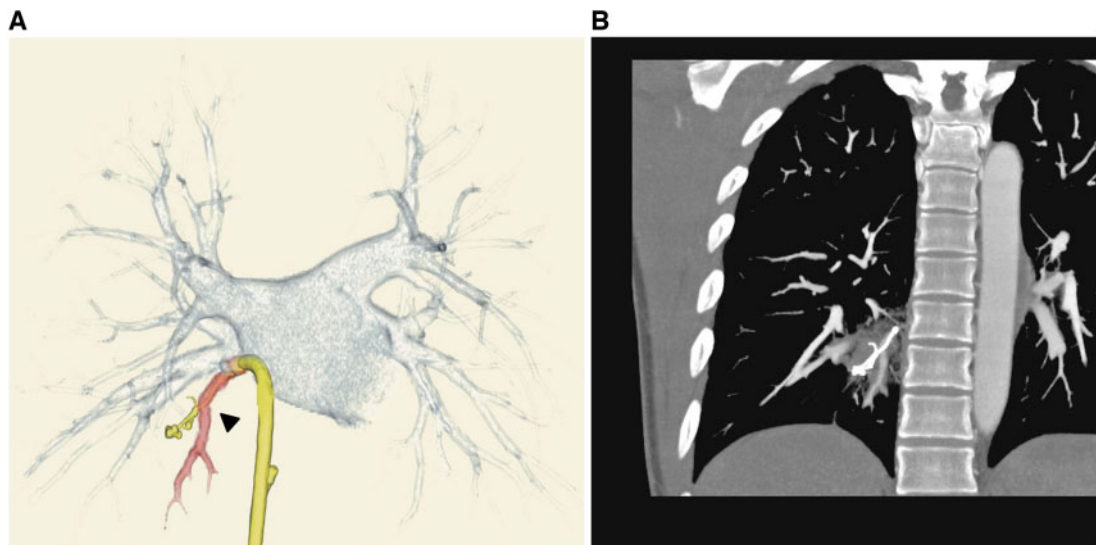


Figure 2 (A) Preoperative three-dimensional constructed enhanced computed tomography shows the catheter tip which perforated the posterior basal vein (red colour) of the right inferior pulmonary vein (triangle). The circular mapping catheter and transeptal catheters are shown in yellow. (B) Preoperative transverse computed tomography (frontal plane) shows the circular mapping catheter and intrapulmonary haemorrhage caused by perforation of the right inferior pulmonary vein (V10: posterior basal vein).

this previous case, in the present case, perforation occurred on the distal side of the RIPV. Therefore, it was considered difficult to reach the perforated site through the LA. Surgery via lateral thoracotomy was selected as the safest and most suitable approach for the removal of the catheter. This method allows the capability of responding to major bleeding after catheter removal and avoids the risk of developing arrhythmias (i.e. atrial

fibrillation, atrial flutter, and atrial tachycardia) associated with open heart incision or additional surgery (i.e. Maze procedure and left appendage exclusion).⁸⁻¹²

In conclusion, lateral thoracotomy was performed for the removal of a circular mapping catheter which caused PV perforation. This case may assist in troubleshooting and problem-solving in case such an event occurs again during procedures in the future.

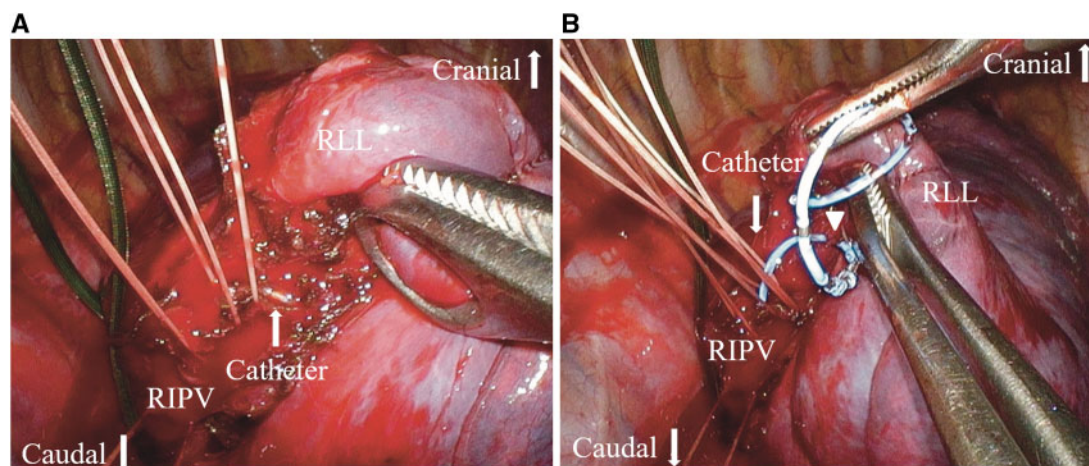


Figure 3 An image captured during the surgery. (A) The circular mapping catheter perforated the right inferior pulmonary vein (V10: posterior basal vein) and was stuck in the right lower lobe. (B) A microincision on the lung parenchyma covering the surface of the catheter tip was performed, and the circular distal portion of the catheter was cut (triangle). RIPV, right inferior pulmonary vein; RLL, right lower lobe.

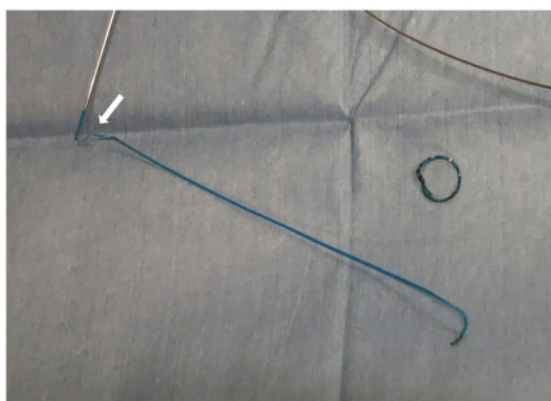
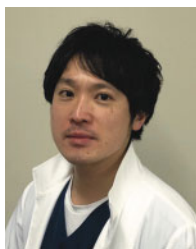


Figure 4 The circular mapping catheter after removal. The junction of the distal portion and the shaft had a fracture (arrow).

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Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

References

1. Kuck K-H, Brugada J, Fürnkranz A, Metzner A, Ouyang F, Chun KRJ et al; FIRE AND ICE Investigators. Cryoballoon or radiofrequency ablation for paroxysmal atrial fibrillation. *N Engl J Med* 2016;**374**:2235–2245.
2. Kulkarni N, Su W, Wu R. How to prevent, detect and manage complications caused by cryoballoon ablation of atrial fibrillation. *Arrhythm Electrophysiol Rev* 2018;**7**:18–23.
3. Massaro RC, Burke JA, Altemose GT. Fracture and retrieval of an Achieve circular mapping catheter in and from a pulmonary vein during cryoballoon ablation for atrial fibrillation. *HeartRhythm Case Rep* 2015;**1**:31–33.
4. Makimoto H, Kelm M, Shin DI, Blockhaus C. Breakage of a circular catheter wedged in a right pulmonary vein during cryoballoon pulmonary vein isolation. *Intern Med* 2017;**56**:1057–1059.
5. 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.

6. Wansa NJ, Paparella G, De Roy LJ. Entrapment and fracture of a 'lasso-like' ACHIEVE catheter in a pulmonary vein branch during isolation by balloon cryoablation. *Europace* 2014;**16**:334–334.
7. Fujiwara R, Takami M, Kijima Y, Masano T, Nagoshi R, Kozuki A et al. A case of an ablation catheter entrapped in the pulmonary vein during atrial fibrillation ablation requiring open heart surgery for removal. *HeartRhythm Case Rep* 2017;**3**:87–89.
8. Gopinathannair R, Mar PL, Afzal MR, Di Biase L, Tu Y, Lakkireddy T et al. Atrial tachycardias after surgical atrial fibrillation ablation: clinical characteristics, electrophysiological mechanisms, and ablation outcomes from a large, multicenter study. *JACC Clin Electrophysiol* 2017;**3**:865–874.
9. Mohanty S, Di Biase L, Trivedi C, Choudhury F, Della Rocca DG, Romero J et al. Arrhythmogenicity and thrombogenicity of the residual left atrial appendage stump following surgical exclusion of the appendage in patients with atrial fibrillation. *J Cardiovasc Electrophysiol* 2019;**30**:339–347.
10. Pap R, Kohari M, Makai A, Bencsik G, Traykov VB, Gallardo R et al. Surgical technique and the mechanism of atrial tachycardia late after open heart surgery. *J Interv Card Electrophysiol* 2012;**35**:127–135.
11. Aktas MK, Khan MN, Di Biase L, Elayi C, Martin D, Saliba W et al. Higher rate of recurrent atrial flutter and atrial fibrillation following atrial flutter ablation after cardiac surgery. *J Cardiovasc Electrophysiol* 2010;**21**:760–765.
12. Jais P, Shah DC, Haissaguerre M, Hocini M, Peng JT, Takahashi A et al. Mapping and ablation of left atrial flutters. *Circulation* 2000;**101**:2928–2934.