Journal of Cardiology Cases 19 (2019) 169–172

Contents lists available at ScienceDirect

Journal of Cardiology Cases

journal homepage: www.elsevier.com/locate/jccase

Case Report

Wire perforation causing cardiopulmonary arrest during radiofrequency hot balloon ablation for pulmonary vein isolation

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ARTICLE INFO

Article history:
Received 18 July 2018
Received in revised form 24 December 2018
Accepted 16 January 2019

Keywords:
Atrial fibrillation
Radiofrequency hot balloon ablation
Complication
Wire perforation
Bronchial-pulmonary venous fistula

ABSTRACT

A 73-year-old woman underwent radiofrequency hot balloon ablation (RHBA) for paroxysmal atrial fibrillation. After delivery into the left inferior pulmonary vein (LIPV), the guidewire perforated the venous wall. We injected contrast medium while the inflated balloon occluded the PV. Subsequently, bronchial-pulmonary venous fistula (BPVF) occurred and the severe hypoxia caused pulseless electrical activity (PEA). Cardiopulmonary resuscitation and intubation quickly recovered spontaneous circulation. She was initially treated by a multidisciplinary team in the intensive care unit and subsequently discharged without sequelae.

Although relatively rare, there are some reports of wire perforation during RHBA and cryoballoon ablation. Some cases resolved after discontinuing anticoagulant therapy, while others required invasive procedures. This is the first case in which hypoxia, shock, and PEA were caused by wire perforation. As such complications can occur in all balloon ablation procedures, operators need to take care when using the guidewire and guide catheter.

Anticoagulant therapy should be discontinued following PV perforation, if possible. Hemostasis with ventilator management is desirable. If hemostasis cannot be achieved, lung resection must be considered. Although wire perforation causing BPVF is rare, establishment of preventive measures and treatment protocols is needed.

<**Learning objective:** The safety of radiofrequency hot balloon (RHB) ablation for paroxysmal atrial fibrillation has been established. This case report presents the rare complication of a soft J-tipped guidewire perforating the pulmonary vein (PV) without any resistance. Pulmonary venography was performed with the RHB blocking the PV, eventually causing pulseless electrical activity from hypoxia due to a bronchial-pulmonary venous fistula. Artificial ventilation management by positive end expiratory pressure after discontinuing anticoagulant therapy was effective for hemostasis and improvement of respiratory condition.>

Introduction

The effectiveness and safety of radiofrequency hot balloon (RHB) ablation (RHBA) for paroxysmal atrial fibrillation (PAF) has already been established. However, previous studies have demonstrated pulmonary vein (PV) stenosis rates of 5.2%, phrenic nerve injury rates of 3.7%, and an esophageal ulceration rate of 5.4% in cases where the luminal esophageal temperature exceeds 43 °C [1,2].

We herein describe a case of PV perforation caused by a soft J-tipped guidewire that lead to iatrogenic pulmonary edema and severe hypoxia with subsequent pulseless electrical activity (PEA).

Case report

A 73-year-old woman with PAF had a history of type 2 diabetes mellitus, hypothyroidism, and necrotizing mediastinitis. She had also experienced repeated episodes of heart failure due to PAF and

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https://doi.org/10.1016/j.jccase.2019.01.001
1878-5409/

atrial flutter (AFL). She had fainted and was transported to a nearby hospital with sinus bradycardia and sinus arrest She was referred to our hospital for catheter ablation and permanent pacemaker implantation.

On admission, electrocardiography showed normal sinus rhythm, which later devolved into PAF with a heart rate of 130 beats per minute. Although she had discontinued oral methyl digoxin and bisoprolol, the PAF stopped and she went into sinus arrest for over 5 s.

We planned PV isolation (PVI) using an RHB catheter (SATAKE Hot-Balloon, Toray Industries, Tokyo, Japan). Three-dimensional atriography revealed that the left inferior PV (LIPV) was relatively small (Fig. 1).

We performed PVI under deep sedation with fentanyl and dexmedetomidine. To prevent injury to the esophagus, we monitored esophageal temperature using the Sensi Therm Esophageal Temperature Monitoring System (St. Jude Medical, Inc., St. Paul, MN, USA).

Whenever the esophageal temperature exceeded 39 °C, we injected water into the esophagus to cool it down. Pacing of the diaphragm from the superior vena cava was performed to avoid injuring the phrenic nerve. Catheter navigation was conducted using a 3D-electroanatomical mapping system (CARTO; Biosense Webster, Diamond Bar, CA, USA). She had been undergoing anticoagulation with 2.5 mg twice daily apixaban, which was stopped on the procedure day. During ablation, we administered heparin intravenously to maintain an activated clotting time between 300 and 400 s.

For transseptal puncture, we inserted the RHB catheter into the left atrium (LA) using a deflectable guiding sheath (Treswaltz; Toray Industries). The balloon was inserted into the target PV by advancing a soft J-tipped guidewire (Spring Guide Wire; Toray Industries). We injected 10–20 ml of contrast medium diluted with saline at a 1:2 ratio into the balloon, which was inflated to 26–33 mm in diameter. Individual isolation of the right superior, right inferior, and left superior PVs was successfully performed at 70 °C for 2 or 3 min.

We inserted the wire into the LIPV and occluded the PV with the inflated balloon as seen on venography. After injecting the contrast medium, we suddenly witnessed abrupt alveolar contrast and backflow to the bronchi (Fig. 2A, B, Supplemental Video). At the same time, massive hemoptysis occurred and severe hypoxia caused PEA. Immediate cardiopulmonary resuscitation and intubation enabled quick recovery of spontaneous circulation.

We believed that a bronchial-pulmonary venous fistula (BPVF) had occurred due to blockage by the balloon without noticing that the soft J-tipped guidewire had perforated the LIPV without any resistance, which was followed by injection of the contrast medium several times at high pressure (Fig. 2B). Chest computed tomography (CT) showed a patchy ground glass opacity widely distributed around the left lung field and consolidation on the dorsal side (Fig. 2C).

We administered protamine to reverse the effect of heparin. Upon entering the intensive care unit (ICU), she had severe respiratory failure with a P/F ratio of 80. Due to her iatrogenic pulmonary edema associated with alveolar hemorrhage and hypoxemia, we started artificial ventilation using low tidal volume ventilation and adequately adjusted positive end-expiratory pressure (PEEP). On the 6th day after perforation, bronchoscopic evaluation revealed continued bleeding from the bronchus (Fig. 2D), and contrast-enhanced CT showed that the peripheral PV wire perforation had changed to a varix. On post-perforation day 14, bronchoscopy showed that the bronchial bleeding had almost disappeared and CT showed that the varix was occluded with thrombus (Fig. 3). Her respiratory condition gradually improved and she was extubated on the 17th day. We performed radiofrequency catheter ablation to create a line of block in the cavotricuspid isthmus for untreated AFL on the 23rd day. Despite the fact that her PAF did not recur, sinus arrest necessitated permanent pacemaker implantation on day 38. She was discharged on the 46th day without sequelae. No PAF or AFL have occurred since then even though the PVI had not been completed in the session. Her medication consisted of diuretic drugs and warfarin 2 mg, without antiarrhythmic agents.

Discussion

The complications associated with RHBA are different from those of cryoballoon ablation (CBA), and include PV stenosis and esophageal ulceration at an overall rate of 1.7%. There have also been reports of cardiac perforation or tamponade with RHBA [3,4]. In this case, the soft J-tipped guidewire had perforated the LIPV without any resistance and pulmonary venography was performed with the RHB blocking the LIPV, causing eventual BPVF.

The soft J-tipped guidewire rarely produces PV perforation. However, in a case similar to ours, another report described LA

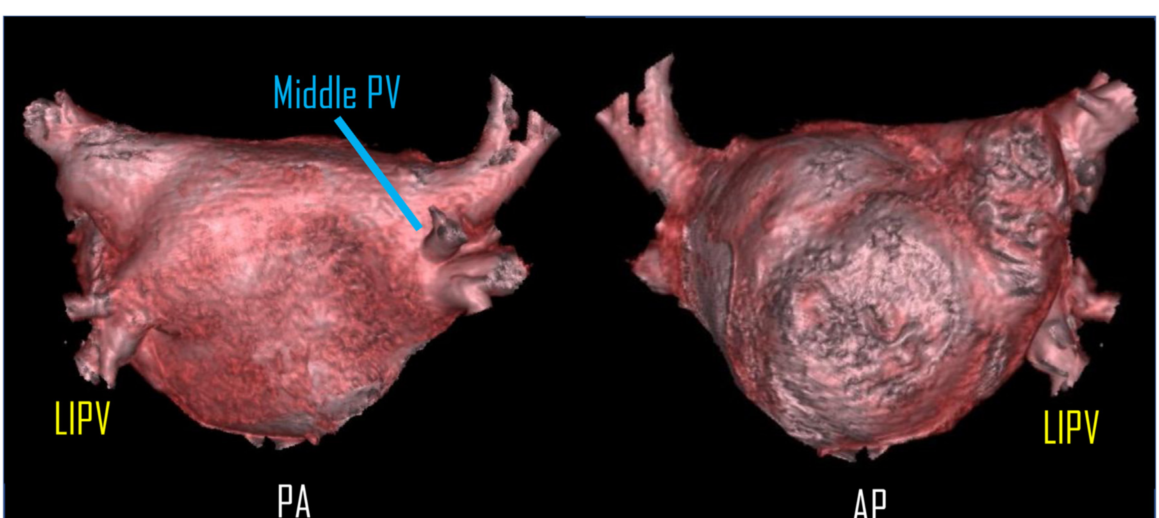

Fig. 1. Three-dimensional atriography of the pulmonary veins. The left inferior pulmonary vein (LIPV) was relatively small and a right middle PV was present.

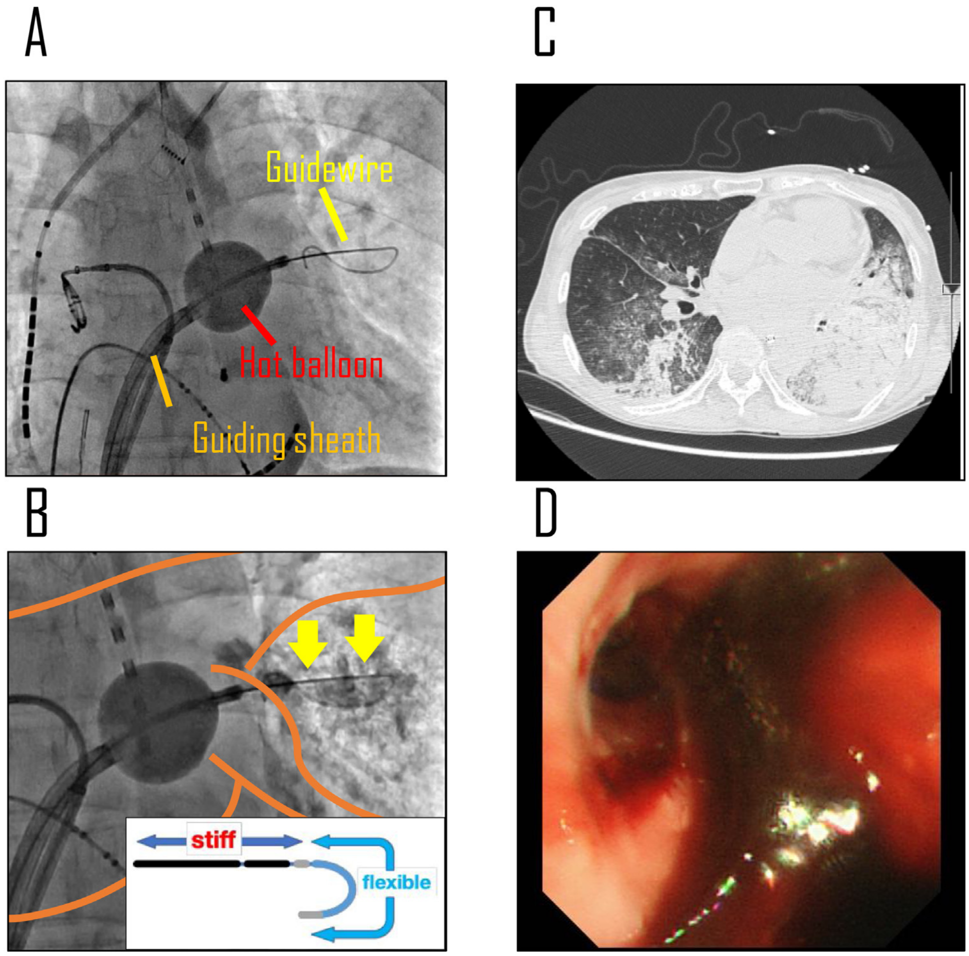

Fig. 2. Venography of wire perforation and postoperative chest computed tomography and bronchoscopic evaluation. (A) Position of the guidewire and balloon before left inferior pulmonary vein (LIPV) angiography. (B) Illustration of left atrium and pulmonary veins (orange outline) and guidewire properties (inset). The tip of the wire turned around in the LIPV and the stiffer proximal segment penetrated the vein (yellow arrows). (C) A patchy, ground glass opacity around the left lung field and consolidation on the dorsal side is shown. (D) Bronchoscopic evaluation revealed the left main bronchus had continuous bleeding and was filled with hematoma.

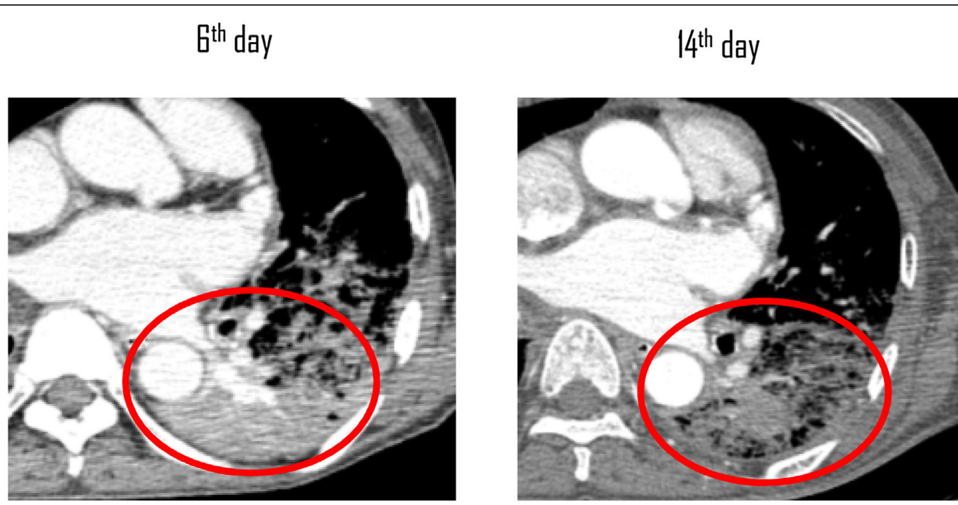

Fig. 3. Contrast-enhanced computed tomography of the varix. Red circles indicate the left inferior pulmonary vein (LIPV). On day 6 of the intensive care unit stay, the perforated LIPV was visible on contrast-enhanced computed tomography. It had disappeared by day 14, indicating thrombus occlusion and hemostasis.

appendage perforation by this device during PVI by RHBA [5]. The authors believed that the wire had advanced into the LIPV on fluoroscopy, but selective angiography revealed that the wire had instead perforated the floor of the LA appendage into the pericardial space. In the case of CBA, we can insert a circular diagnostic catheter into the PV while confirming electrical potential; however, with RHBA, there is no electrode on the guidewire, and we have to insert it into the PV using fluoroscopy.

The distal segment of the wire is flexible and gradually stiffens to enable the balloon to maintain its coaxial position. In our case, it was possible that the tip of the wire had turned around in the LIPV to cause the perforation while the proximal segment continued to advance, exacerbating the perforation (Fig. 2B). With the PV injury undetected on fluoroscopy, angiography was performed at high pressure and caused the BPVF, leading to severe hypoxia and PEA.

To our knowledge, this is the first case of PEA caused by PV perforation during balloon ablation. Another interesting finding in this case was that artificial ventilation by PEEP after discontinuing anticoagulant therapy was effective for hemostasis. One report described that CBA had caused pulmonary hemorrhage by directly injuring the lungs and bronchi surrounding the PV [6]. As discontinuing anticoagulants resulted in hemostasis, we also opted for heparin neutralization and drug cessation. Upon entering the ICU, she had severe respiratory failure with a P/F ratio of 80. Excessive pressure and ventilation to maintain oxygenation may have led to lung injury. Therefore, we focused on prompt improvement of respiratory function while avoiding ventilator-associated lung injury by using low tidal volume ventilation and adequately adjusted PEEP [7]. Although her respiratory condition improved, if insufficient ventilation on the affected side due to a difference in pulmonary compliance had occurred, we would have attempted differential lung ventilation, and possibly extracorporeal membrane oxygenation. Lung resection would have also been an option for persistent active bleeding.

The circular catheter used in CBA may also lead to similar complications to the soft J-tipped guidewire used in RHBA. This catheter has been reported to cause intramural hematomas in small PVs [8], as well as breaking off in a small PV branch and remaining in the lung parenchyma [9]. If the guide catheter is at risk of causing perforation, a similar phenomenon may occur in all balloon ablation procedures, including CBA. Therefore, care is required during manipulation of the guidewire and guide catheter. Since perforation is more likely in small PVs, angiography after PV balloon occlusion should be gentle, and the position of the guidewire tip must be confirmed at every angle.

We should also be careful in manipulating the guidewire in small PVs, and consider a more flexible guidewire, such as that from an SL-0 sheath. When performing balloon ablation for elderly patients with reduced respiratory function in particular, care must be taken to avoid complications of PV perforation with a softer wire. Evaluating the morphology of the PV on preoperative CT and considering the patient's general condition and comorbidities are crucial to developing the best ablation therapy strategy.

It was noteworthy that our patient was deeply sedated during ablation. If she had been awake or under mild sedation, she might have reacted to any pain. Furthermore, if angiography had been performed following early detection of perforation, her lung injury might have been milder.

Future studies are needed to verify that the measures proposed in this case are valid for similar balloon ablation cases.

Conflict of interest

The authors declare that there is no conflict of interest.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jccase.2019.01.001.

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