Pressure guided pulmonary vein isolation by means of a novel cryoballoon technology for the management of complex anatomy: A case report

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Introduction

Catheter ablation through pulmonary vein (PV) isolation (PVI) is a cornerstone of therapy for symptomatic atrial fibrillation (AF).[1] Irrespective of the technologies and energy source used (eg, cryothermic or radiofrequency energy), it is necessary to create a continuous ablation line resulting in durable lesions, in order to achieve complete electrical isolation of the PV. Several studies have shown that the magnitude of PV occlusion during cryoablation (CB) is a significant determinant of PVI durability.[2] Vein occlusion is generally verified by injecting contrast medium into the lumen at the tip of the balloon. However, recent studies with the Arctic Front CB (Medtronic, Minneapolis, MN) have demonstrated that monitoring the PV pressure waveform and its changes could be an alternative method of confirming occlusion and predicting successful PVI.[3,4] The utility of pressure waveform analyses in assessing PV occlusions achieved by means of various technologies and in the presence of anatomical variants of the PV has not yet been studied. Here, we report the first case of pressure-guided PVI by means of the new POLARx CB system (Boston Scientific, St. Paul, MN) during PVI in a patient with complex anatomy.

Case report

A 72-year-old man with a history of paroxysmal AF and previous ablation of typical atrial flutter was admitted to our hospital for PVI. The procedure was performed under conscious sedation and local anesthesia. After transseptal catheterization, the CB catheter was inserted into the left atrium via a 15.9F steerable sheath (POLARSheath; Boston Scientific, St. Paul, MN). Mapping of the PVs was performed by means of a 20 mm inner lumen circular mapping catheter with 8 electrodes (POLARMap™; Boston Scientific, St. Paul, MN). The mapping catheter was advanced into each PV ostium and positioned as proximally as possible, in order to record PV potentials. A 28 mm, short-tip (5 mm tip) CB (POLARx™; Boston Scientific) was advanced, inflated, and positioned at each PV antrum. Optimal vessel occlusion was carried out only on the basis of analysis of the pressure curve obtained at the tip of the CB catheter, without injecting contrast medium. This pressure curve was obtained by connecting the internal lumen of the catheter to a pressure transducer, which was connected in turn to a bag of heparinized saline serum and the LSPRO Polygraph System (Boston Scientific, St. Paul, MN). The curves were interpreted by analyzing the morphology of the pressure wave, as well as the absolute variation in the pressure obtained, reflected in the LSPRO Polygraph System.

Since the patient was in sinus rhythm, the A and V waves were recorded before occlusion. In this procedure, there is a loss of the A wave and a change in the amplitude (increase) and morphology of the V wave when the vein is occluded (Figure 1A). By contrast, when the balloon does not occlude the ostium of the PV, a characteristic left atrial pressure is recorded, thus leading to a different A-V waveform (Figure 1B). We measured the pressure at each PV before and after balloon inflation. These measurements were taken after waiting 10 seconds for the pressure waveform to stabilize and during the expiratory phase (Figure 1A and 1B). For each vein, the application time was calculated as the time-to-

KEY TEACHING POINTS

- Real-time evaluation of the pressure waveform can be easily used to complement other occlusion criteria, such as the injection of radiopaque contrast medium, thereby facilitating effective pulmonary vein (PV) occlusion.
- Monitoring the pressure waveform can predict PV occlusion during cryoablation.
- A pressure guided PV approach may help to guide successful PV isolation while reducing the use of intravenous contrast media.

KEYWORDS Atrial fibrillation; Cryoballoon ablation; POLARx; PVI; Occlusion; Pressure
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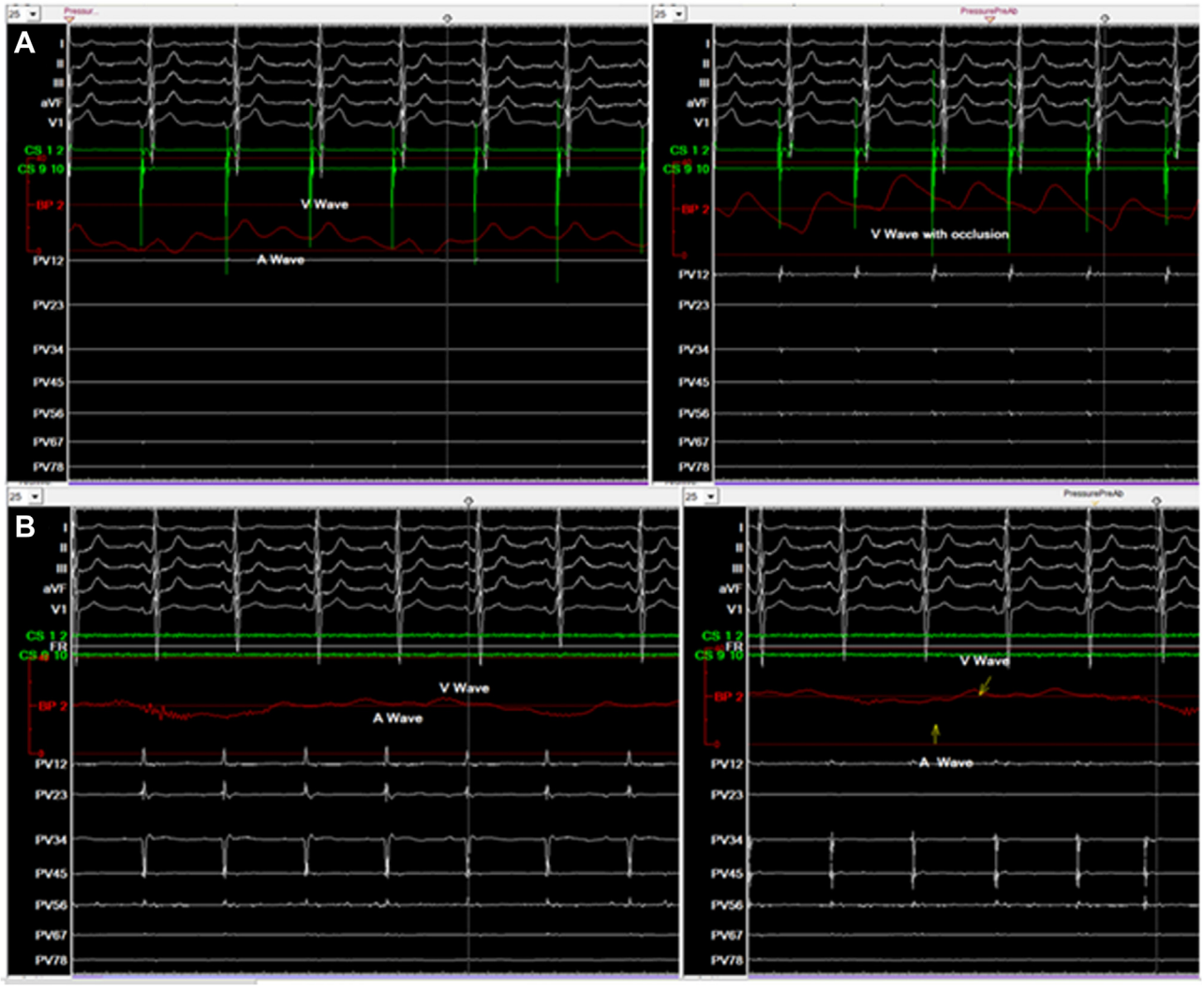

Figure 1 **A:** An example of transition from a nonoccluded left atrial pressure waveform (left) to a fully occluded waveform (right). At the beginning of the procedure, both A and V waves are present, indicating that the cryoballoon is not occluding the pulmonary vein. After the transition, only dominant V waves are present, indicating complete balloon occlusion. **B:** A case of nonocclusion; both A and V waves are present before (left) and after (right) inflation.

isolation (TTI). Protocol-directed CBAs were delivered for 180 seconds or 240 seconds if isolation was achieved in ≤60 seconds, or for 240 seconds if isolation occurred in >60 seconds or when TTI was not available.

During the CBA of the right inferior PV (RIPV), analysis of the pressure wave showed a clear nonocclusive morphology and we did not record any TTI. We then advanced and retracted the balloon several times, and also changed the CB orientation, in an attempt to achieve good occlusion, but without success. We therefore injected contrast medium to verify the positioning of the CB, and detected a complex anatomy with an additional inferior vessel. We then mapped the LA by means of the Orion™ (Boston Scientific, St. Paul, MN) basket catheter and the Rhythmia™ (Boston Scientific, St. Paul, MN) mapping system, focusing on the RIPV. This confirmed the presence of a large ostium (>32 mm as measured by the mapping tool) with a right accessory PV (Figure 2A). After repositioning the CB, we then achieved PVI with an additional freeze of 180 seconds (TTI = 40 seconds, nadir temperature of -54°C, thaw time 20 seconds).

At the end of the procedure (total procedure time = 67 minutes, total fluoroscopic time = 17.5 minutes), PVI, as assessed by entrance and exit block, was verified at each PV by means of the POLARMap catheter, which was placed at the ostium of each PV (Figure 2B). Over 6 months' follow-up, no AF recurrence was reported by the patient.

Discussion

We report the first case of a pressure waveform–guided PVI procedure performed with the novel POLARx CB in a patient with complex PV anatomy. Monitoring the pressure waveform allowed us to predict PV occlusion during CB ablation and helped to achieve successful PVI in the presence of an anatomical variant of the RIPV.

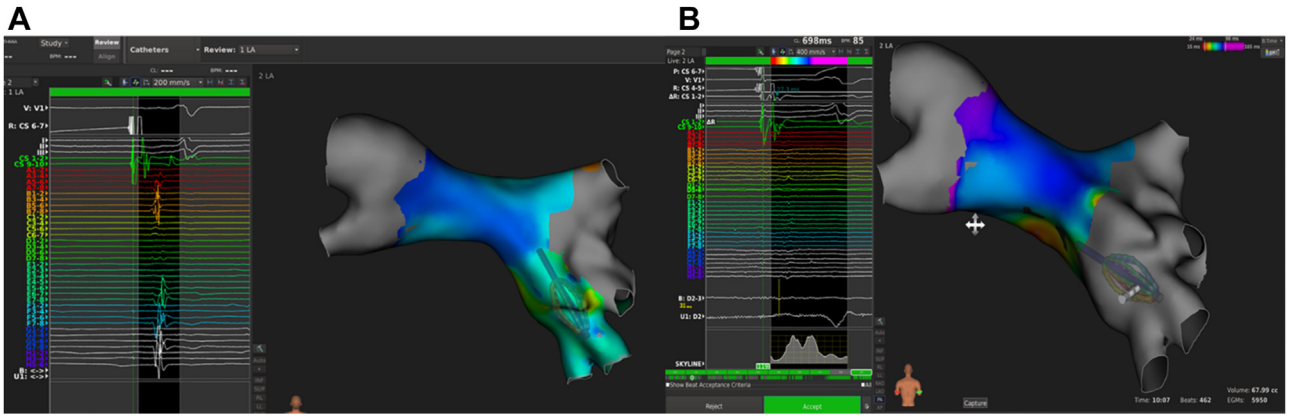

Figure 2 Mapping the left atrium and the right inferior pulmonary vein (RIPV) by means of the Orion basket catheter with the Rhythmia mapping system confirmed the presence of a large ostium (>32 mm as measured by the mapping tool) with a right accessory pulmonary vein (PV). **A:** The RIPV was not isolated and displayed a clear connection to the antral portion of the PV. **B:** Having remapped the RIPV and the left atrium after repositioning the cryoballoon, we achieved PVI with an additional freeze of 180 seconds.

PV occlusion is a significant determinant of acute PVI and durable success. It is commonly assessed by means of intravenous injection of a radiopaque contrast medium through the lumen after balloon inflation at the PV ostium. Conversely, contrast leakage upon balloon inflation confirms incomplete PV occlusion by the CB. However, this technique carries the risk of contrast exposure, such as allergic reactions and renal injury, especially in patients with chronic kidney disease.[3] The lack of continuous feedback during the initial balloon positioning is also a disadvantage of this technique.[3]

Several authors have proposed alternative methods of predicting PV occlusion, including a pressure-guided method whereby the change in the pressure waveform at the distal tip of the CB is recorded.[3–5] During CBA with the Arctic Front CB (Medtronic), pressure waveform analysis without the routine use of pulmonary venography has proved to be a reliable method of determining PV occlusion.[5] In addition, several authors have shown that the procedural success rate of the pressure-guided technique for PVI is as effective and safe as conventional CB PVI,[3] while also allowing fluoroscopy to be reduced.[6] Most importantly, clinical outcomes after the use of this technique have compared favorably with those reported when pulmonary venography is routinely used.[5]

Using a different CB technology (POLARx), applying the same workflow and analyzing the PV pressure curve recorded at the tip of the catheter, we were able to easily achieve PVI in all the "standard" PVs without using contrast medium. However, when faced with a complex PV anatomy—ie, a large ostium with an additional inferior vessel—real-time pressure waveform analysis suggested that we could not achieve PVI without further investigating the characteristics of the PV; we therefore used a contrast medium and the 3D mapping system only from that moment onward, to elucidate the peculiar anatomy.

Our case confirms that real-time evaluation of the pressure waveform can be used to complement other occlusion criteria, such as the injection of radiopaque contrast medium, thereby facilitating effective PV occlusion. Indeed, using a pressure wave tool in combination with a balloon that can be sized as needed, such as in the presence of a very large ostium, could be of great help both in routine management and in that of complex anatomies, minimizing the use of fluoroscopy. As this is a case report, we are not able to adequately investigate other possible factors associated with effective PVI or to make direct comparisons among different methods of evaluating PV occlusion. The wave characteristics reflect the pressure differential between the atrium and the PV and consequently the resulting waveform is affected by initial and ending condition; therefore the underlying rhythm should be the same before and after pressure waveform measurement to ensure proper assessment. Finally, neither the clinical effect nor the long-term outcome was evaluated. Further prospective studies are needed in order to investigate these aspects in depth and to evaluate improved procedural efficiency.

Conclusion

Monitoring the pressure waveform can predict PV occlusion during CB ablation and may help to guide successful PVI while reducing the use of intravenous contrast media.

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