Single-shot antral isolation of a common pulmonary vein by the hot balloon

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Introduction

Balloon-based ablation modalities such as the cryoballoon (CB) and hot balloon (HB) have been developed to simplify pulmonary vein (PV) isolation, with favorable outcomes.[1–3] Nonetheless, a left common PV trunk (LCPV) of the superior and inferior PVs is not rare and the incidence has been reported to be 9%–83%.[4,5] The balloon adaptability to this anatomic variation is challenging, especially in CB-based ablation because of its fixed balloon size. In our case series, the HB facilitated the occlusion and isolation of the LCPV antrum by an adjustment of the enlarged balloon size.

Hot balloon ablation

HB ablation details have been previously described.[2] In brief, SATAKE Hot Balloon (Toray Industries, Inc, Tokyo, Japan) with an inner lumen and J-tip guidewire was inflated at each PV ostium through a 13F deflectable guiding sheath (Treswaltz, Toray Industries) via a transseptal approach. PV occlusion was achieved by inflating the HB to 26–33 mm in diameter with 10–20 mL of contrast medium diluted 1:2 with saline, and was confirmed by venography. A radiofrequency (RF) current of 1.8 MHz was delivered between the coil electrode inside the HB and 4 cutaneous electrode patches on the patient's back to produce capacitive-type heating of the HB. For LCPV isolation, the RF-generated thermal energy with the target internal balloon temperature of 70°C or 73°C, maintained by delivery of vibratory waves through the lumen into the balloon to agitate the fluid inside, was applied for 180 seconds. RF-generated thermal energy with the same balloon was also applied to the right superior PV antrum for 210 seconds and to the right inferior PV antrum for 150 seconds following LCPV isolation. The esophageal temperature was monitored during application of thermal energy to avoid esophageal injury. When the temperature exceeded 39°C, cold saline was injected into the esophagus through a nasoesophageal tube, and was aspirated out of the stomach following this maneuver. Phrenic nerve pacing was performed and compound motor action potentials were recorded and monitored in all cases during application of thermal energy to the right-sided PV.

KEY TEACHING POINTS

- Antral isolation for a left common pulmonary vein trunk (LCPV) of the superior and inferior pulmonary veins is challenging because of the balloon inadaptability to the large common ostium.
- Hot balloon facilitates the occlusion and isolation of the LCPV antrum by an adjustment of the enlarged balloon size, which might help avoid pulmonary vein stenosis following a distal segmental ablation.
- Study of the long-term outcome of a single-shot antral isolation of a common pulmonary vein with hot balloon would be warranted.

Case reports

Case 1

A 50-year-old man with paroxysmal atrial fibrillation (AF) underwent PV isolation with an HB (Satake, Toray Industries, Inc, Tokyo, Japan). Contrast-enhanced computed tomography revealed an LCPV with an ostial diameter of 33 × 20 mm and ostial area of 640 mm^2 (Figure 1A). The HB was inflated to 33 mm in diameter with 20 mL of diluted contrast medium guided by the atriogram (Figure 1B) and achieved an antral occlusion of the LCPV (Figure 1C). A thermal application with a target internal balloon temperature of 73°C and duration of 180 seconds successfully isolated the LCPV, which was confirmed by a left atrial voltage map (EnSite NavX Velocity; Abbott Laboratories, Abbott Park, IL) with a 20-pole circular mapping catheter (4-mm interelectrode spacing; Inquiry AFocus II, Abbott,

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Informed consent was obtained for experimentation with human subjects. **Address reprint requests and correspondence:** Dr Koichi Nagashima, Division of Cardiology, Department of Medicine, Nihon University School of Medicine, 30-1 Ohyaguchi-kamicho, Itabashi-ku, Tokyo 173-8610, Japan. E-mail address: cocakochan@gmail.com.

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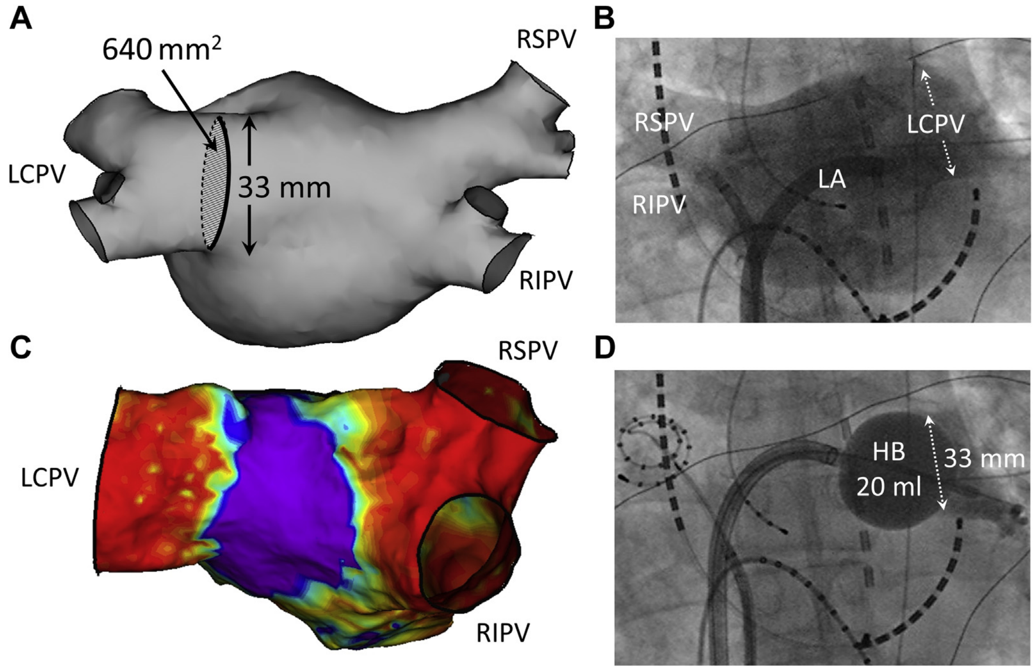

Figure 1 Three-dimensional reconstructed left atrial image (**A**), left atriography (**B**), antral occlusion of the common trunk of the left pulmonary veins by the hot balloon (**C**), and voltage map after an antral isolation of a left common pulmonary vein (**D**). On the voltage map, the *purple areas* are high-voltage zones with a bipolar electrogram amplitude of ≥0.5 mV. The *red*, *orange*, *yellow*, *green*, and *blue areas* are low-voltage zones of <0.5 mV, ie, ablation lesions. HB = hot balloon; LA = left atrium; LCPV = left common pulmonary vein; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein.

Figure 1D). No dormant PV conduction was revealed by an injection of 30 mg of adenosine triphosphate. No AF recurrence was detected during a follow-up period of 6 months.

Cases 2–5

The common PVs and ablation features with a successful antral isolation of the common PVs are shown in Table 1 and Figure 2. A single-shot antral isolation was successful in all patients. None had AF recurrence during a follow-up period of 6 months with median and interquartile ranges.

In our case series, the mean maximal diameter of the LCPV was 30 ± 4 mm (range 25–33 mm), and the mean ostial area was 510 ± 140 mm^2 (range 360–640 mm^2).

Discussion

PV antral isolation contributes to a better ablation outcome compared with a segmental isolation, because some triggers originate from the PV antrum.[6,7] However, the balloon-based antral isolation of a large common PV is challenging. Heeger and colleagues[8] and Ströker and colleagues[9] reported that a successful antral isolation by a CB is limited for LCPVs with a diameter of 27 ± 6 mm (32 mm of maximum) and an ostial area of 305 ± 109 mm^2 because of its fixed size and lesser compliance.[8,9] Although a larger common PV can be reluctantly isolated by CB with multiple, separate freeze deliveries at the distal branches of the common PV, a single-shot antral isolation would be desirable to avoid PV stenosis.[10] Therefore, in contrast to the CB, the HB facilitates the occlusion and isolation of the LCPV antrum by an adjustment of the enlarged balloon size, which might help avoid PV stenosis following a distal segmental ablation. In our case series (cases 1–4), the mean maximal diameter and area of the LCPV ostium were 30 ± 4 mm and 510 ± 140 mm^2, respectively. Given

Table 1 Clinical and anatomic features in cases with a successful common pulmonary vein antral ablation by a hot balloon

Case	Age	Sex	Common PV	Maximum diameter	Area of ostium	Fluid injection into HB	Application	Number of venograms*	Total contrast medium use†	Total fluoroscopy count†	Total procedure time‡	AF recurrence (follow-up period)
1	50	M	Left	33 mm	640 mm^2	20 mL	73°C, 180 s	5	80 mL	224.74 mGy	155 min	No (6 months)
2	69	F	Left	33 mm	640 mm^2	16 mL	70°C, 240 s	1	80 mL	216.07 mGy	157 min	No (1 year)
3	67	F	Left	28 mm	360 mm^2	16 mL	73°C, 180 s	5	90 mL	95.52 mGy	90 min	No (6 months)
4	70	M	Left	32 mm	560 mm^2	12 mL	73°C, 180 s	2	50 mL	108.44 mGy	92 min	No (3 months)
5	66	M	Right	25 mm	360 mm^2	19 mL	70°C, 240 s	6	100 mL	135.51 mGy	139 min	No (6 months)

AF = atrial fibrillation; F = female; HB = hot balloon; M = male; PV = pulmonary vein.
*The number of venograms required for common pulmonary vein occlusion.
†Quantity required to isolate all pulmonary veins.
‡Time from puncture to end of the procedure.

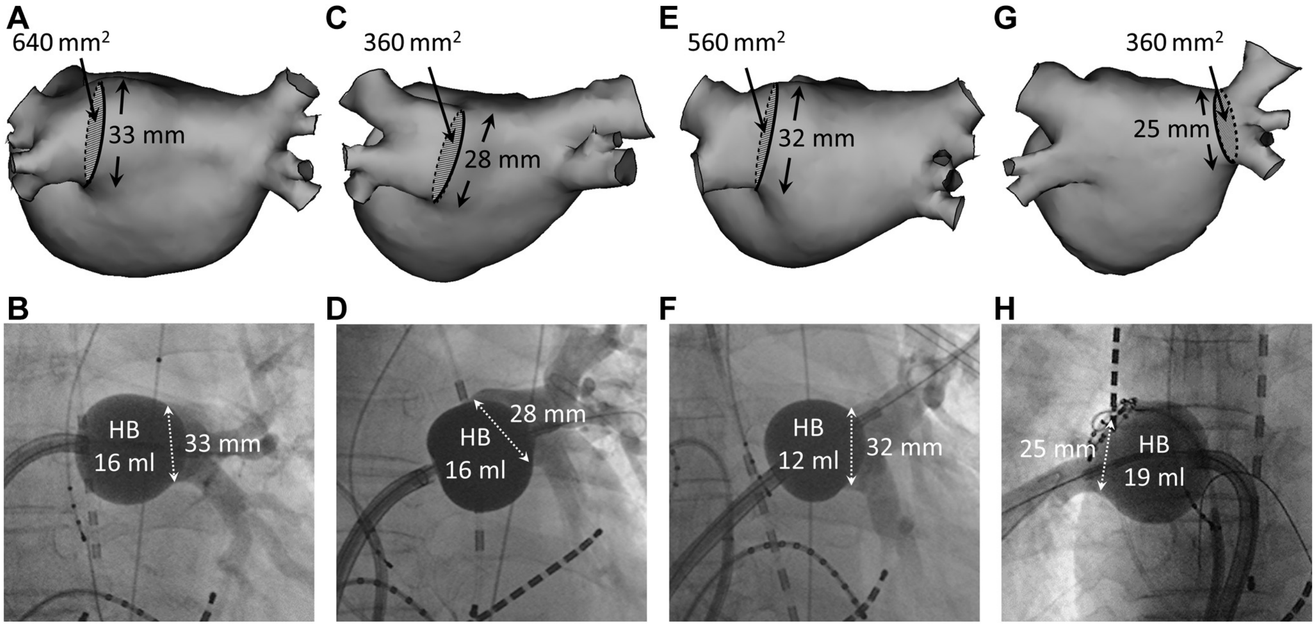

Figure 2 Three-dimensional reconstructed left atrial image and fluoro images of the antral occlusion of the common trunk of the pulmonary veins by the hot balloon (HB) in cases 2 (**A, B**), 3 (**C, D**), 4 (**E, F**), and 5 (**G, H**). In case 2, the left common pulmonary vein (LCPV) ostium was 33 × 26 mm in diameter and 640 mm^2 in area, which was isolated by the HB inflated with a fluid injection of 16 mL. In case 3, the LCPV ostium was 38 × 20 mm in diameter and 360 mm^2 in area, which was isolated by the HB inflated with a fluid injection of 16 mL. In case 4, the LCPV ostium was 32 × 23 mm in diameter and 560 mm^2 in area, which was isolated by the HB inflated with a fluid injection of 12 mL. In case 5, the right common pulmonary vein ostium was 25 × 17 mm in diameter and 360 mm^2 in area, which was isolated by the HB inflated with a fluid injection of 19 mL.

these results, HB ablation might be useful for a large LCPV antral isolation. Furthermore, the HB might also be adaptable for right common PVs (case 5). However, the feasibility of the single-shot antral isolation of the excessively large LCPV (>33 mm) remained unknown. In those cases, the separate thermal applications at the distal branches of the common PV might be required even with HB.

Previous reports indicated that a PV antral isolation was more likely to cause injury of the esophagus and periesophageal vagal nerve,[11,12] but no patients had any serious complications, such as esophageal injury, phrenic injury, cardiac tamponade, or PV stenosis, during or after the procedure. However, the durability is of major concern, although no AF recurrence was detected in any of the patients during at least 3 months. Because the mechanism of HB ablation is a capacitive-type heating of the balloon, excessive balloon inflation to adapt for a large ostium may reduce the balloon surface temperature, which has the potential for common PV reconnections. The long-term outcomes of single-shot antral isolation of common PVs is worthy of future study.

Conclusion

The single-shot antral isolation by the HB might be useful for large common PVs. The long-term durability of a single-shot antral isolation of a common PV is worthy of further study.

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