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

Yuji Wakamatsu, MD, Koichi Nagashima, MD, PhD, Ryuta Watanabe, MD, Masaru Arai, MD, Naoto Otsuka, MD, Yasuo Okumura, MD, PhD

From the Division of Cardiology, Department of Medicine, Nihon University School of Medicine, Tokyo, Japan.

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. 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%. 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. 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–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.

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 mm² (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, Illinois, USA). The patient was discharged without any related complications.

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.
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 mm² (range 360–640 mm²).

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 colleagues8 and Ströker and colleagues9 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 mm² 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 mm², respectively. Given

| 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 mm²        | 20 mL                  | 73°C, 180 s | 5                    | 80 mL                    | 224.74 mGy               | 155 min        | No (6 months)               |
| 2    | 69  | F   | Left      | 33 mm           | 640 mm²        | 16 mL                  | 70°C, 240 s | 1                    | 80 mL                    | 216.07 mGy               | 157 min        | No (1 year)                |
| 3    | 67  | F   | Left      | 28 mm           | 360 mm²        | 16 mL                  | 73°C, 180 s | 5                    | 90 mL                    | 95.52 mGy                | 90 min         | No (6 months)               |
| 4    | 70  | M   | Left      | 32 mm           | 560 mm²        | 12 mL                  | 73°C, 180 | 2                    | 50 mL                    | 108.44 mGy               | 92 min         | No (3 months)               |
| 5    | 66  | M   | Right     | 25 mm           | 360 mm²        | 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.
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, 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.

References
1. Kuck KH, Brugada J, Furnkranz A, et al. Cryoballoon or radiofrequency ablation for paroxysmal atrial fibrillation. N Engl J Med 2016;374:2235–2245.
2. Nagashima K, Okamura Y, Watanabe I, et al. Hot balloon versus cryoballoon ablation for atrial fibrillation: lesion characteristics and middle-term outcomes. Circ Arrhythm Electrophysiol 2018;11:e005861.
3. Sohara H, Ohe T, Okumura K, et al. HotBalloon ablation of the pulmonary veins for paroxysmal AF: a multicenter randomized trial in Japan. J Am Coll Cardiol 2016;68:2747–2757.
4. Jongbloed MR, Dirksen MS, Bax JJ, et al. Atrial fibrillation: multi-detector row CT of pulmonary vein anatomy prior to radiofrequency catheter ablation–initial experience. Radiology 2005;234:702–709.
5. Thorning C, Hamady M, Liaw JV, et al. CT evaluation of pulmonary venous anatomy variation in patients undergoing catheter ablation for atrial fibrillation. Clin Imaging 2011;35:1–9.
6. Oral H, Scharf C, Chugh A, et al. Catheter ablation for paroxysmal atrial fibrillation: segmental pulmonary vein ostial ablation versus left atrial ablation. Circulation 2003;108:2355–2360.
7. Ouyang F, Ernst S, Chun J, et al. Electrophysiologic findings during ablation of persistent atrial fibrillation with electroanatomic mapping and double Lasso catheter technique. Circulation 2005;112:3048–3052.
8. Heeger CH, Tscholl V, Wisser E, et al. Acute efficacy, safety, and long-term clinical outcomes using the second-generation cryoballoon for pulmonary vein isolation in patients with a left common pulmonary vein: a multicenter study. Heart Rhythm 2017;14:1111–1118.
9. Stroker E, Takarada K, de Asmundis C, et al. Second-generation cryoballoon ablation in the setting of left common pulmonary veins: procedural findings and clinical outcome. Heart Rhythm 2017;14:1318–1324.
10. Kuck KH, Furnkranz A. Cryoballoon ablation of atrial fibrillation. J Cardiovasc Electrophysiol 2010;21:1427–1431.
11. Pappone C, Oral H, Santinelli V, et al. Atrio-esophageal fistula as a complication of percutaneous transcatheater ablation of atrial fibrillation. Circulation 2004;109:2724–2726.
12. Bunch TJ, Ellenbogen KA, Packer DL, Asirvatham SJ. Vagus nerve injury after posterior atrial radiofrequency ablation. Heart Rhythm 2008;5:1327–1330.