

Long-term outcome of repeat balloon angioplasty for pulmonary vein stenosis after radiofrequency ablation: A case series



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Introduction

Pulmonary vein stenosis (PVS) after pulmonary vein isolation (PVI) for atrial fibrillation (AF) is a rare but serious complication with significant morbidity.¹ The optimal treatment strategy for symptomatic PVS remains unknown. Stenting is preferred to balloon angioplasty (BA) because it has a lower incidence of restenosis than BA.^{2–5} However, the incidence of stent restenosis is reported to be up to 25% during a 3-year follow-up.² Moreover, appropriate antithrombotic therapy after stenting is unknown. Hence, we positioned BA as the first-choice intervention to relieve symptomatic PVS at our institution. In this case series, we report the long-term follow-up of repeat BA for symptomatic PVS after PVI.

Case report

This study included 5 consecutive patients (median age, 52 years [range, 44–52 years]; 4 were male) who underwent BA for symptomatic PVS at the National Cerebral and Cardiovascular Center (Osaka, Japan) between 2012 and 2023 (Table 1). PVS was defined as a reduction in PV luminal diameter and was classified as mild (<50%), moderate (50%–70%), or severe (>70%) (Figure 1A).⁶ All patients had PVS-related symptoms, such as dyspnea on exertion (DOE), hemoptysis, and cough. BA was conducted as follows (Figure 1B): (1) after insertion of steerable sheath (Agilis NxT; Abbott Medical, St Paul, MN) into the left atrium, angiography of the target pulmonary vein was performed under rapid pacing from the right ventricle; (2) angioplasty wire (Aguru™ Peripheral Guidewire, Boston Scientific, Marlborough, MA) was advanced into the stenosed PV and used to position a balloon; and (3) the PV was dilated by the balloon

KEY TEACHING POINTS

- For symptomatic pulmonary vein stenosis after catheter ablation, stenting is preferred to balloon angioplasty (BA) because it has a lower incidence of restenosis than BA. However, the incidence of stent restenosis is relatively high. Appropriate antithrombotic therapy after stenting is unknown.
- We showed that repeat BA was associated with a high incidence of restenosis; however, it can maintain pulmonary vein patency to the extent that it does not worsen clinical symptoms.
- Repeat BA may be considered as a treatment option for recurrent pulmonary vein stenosis.

and checked by PV angiography. After the initial procedure, a second procedure was performed at the physician's discretion when restenosis was observed or when patients experienced symptom recurrence. The treatment details are shown in Table 2.

Case 1

A 44-year-old woman with Takayasu disease presented with severe symptomatic PVS in the right superior pulmonary vein (RSPV) and right inferior pulmonary vein (RIPV) 3 months after PVI. She underwent 5 BAs for the recurrence of severe PVS in the RSPV and RIPV associated with DOE and hemoptysis for 29 months. During the fifth BA, cardiac tamponade occurred, however, the patient recovered without experiencing any complications apart from pericardiocentesis. After the fifth BA, contrast-enhanced computed tomography revealed 42% stenosis of the RSPV and 99% stenosis of the RIPV. The patient remained asymptomatic and free from hemoptysis for 72 months. During the follow-up period, AF recurrence was not observed.

KEYWORDS Pulmonary vein stenosis; Balloon angioplasty; Stenting; Pulmonary vein isolation; Catheter ablation (Heart Rhythm Case Reports 2025;11:142–145)

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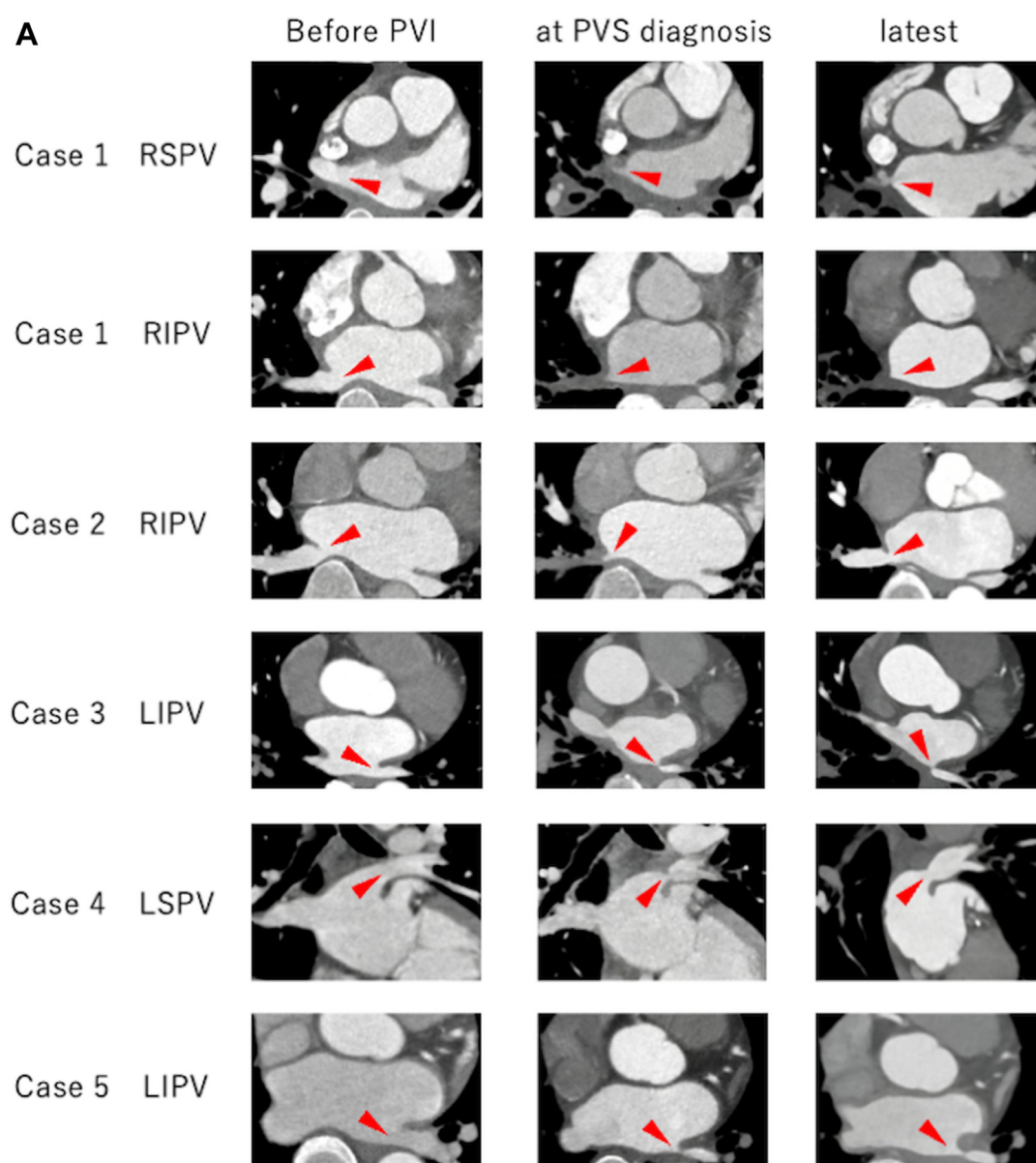


Figure 1 **A:** Computed tomography image showing the pulmonary vein. The *left, middle, and right columns* show contrast-enhanced computed tomography images before pulmonary vein isolation at the time of diagnosis of pulmonary vein stenosis (PVS) and at final follow-up, respectively. The *red arrows* indicate the PVS sites. **B:** Pulmonary angiography of the representative case (case 4, second balloon angioplasty). The *left, middle, and right columns* show pulmonary angiography during the procedure of balloon angioplasty before, during, and post balloon dilation, respectively. The *red arrows* indicate the PVS sites. LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein.

Case 2

A 52-year-old man presented with severe symptomatic RIPV stenosis 2 months after PVI. BA for the RIPV stenosis relieved his symptoms. Follow-up contrast-enhanced computed tomography performed 4 months after the initial BA showed restenosis of the RIPV, despite the absence of symptoms. Seven months after the initial BA, the patient underwent a second BA, which improved the grade of stenosis from severe to moderate. The patient remained asymptomatic for 60 months after the first BA. During the follow-up period, AF recurrence was not observed.

Case 3

A 55-year-old man underwent PVI for paroxysmal AF. Seven months later, he underwent a second PVI for recurrent AF. He presented with severe symptomatic stenosis of the left inferior pulmonary vein (LIPV) 2 months after PVI. BA was performed on the LIPV, which had been electrically isolated at the time of the procedure. PVI on the right PV for recurrent AF was simultaneously performed. He had undergone 3 BAs for LIPV stenosis associated with DOE and left pleural effusion for 23 months. However, 11 months after the third procedure, the patient experienced severe LIPV restenosis associated with DOE.

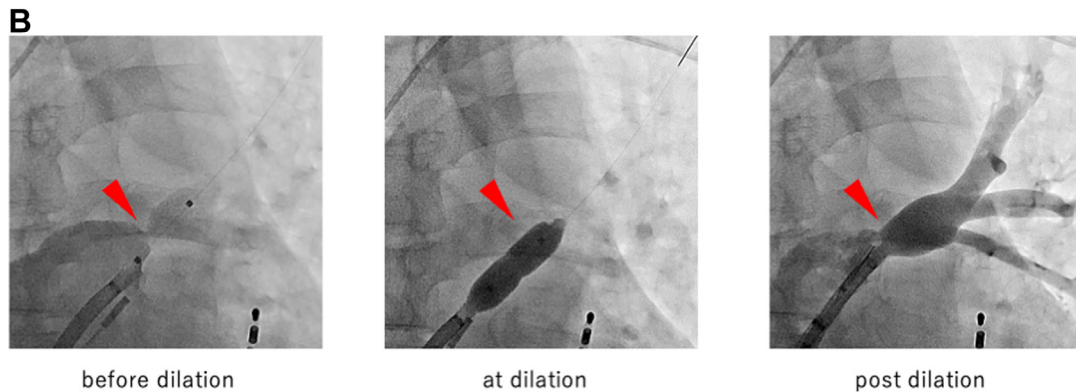


Figure 1 (continued).

Case 4

A 45-year-old man presented with severe symptomatic stenosis of the left superior pulmonary vein (LSPV) 4 months after PVI. Although DOE completely resolved after the first BA, the patient had recurrent AF associated with palpitation 92 months after the BA. Contrast-enhanced computed tomography performed prior to the ablation procedure revealed moderate LSPV restenosis. The patient underwent a second BA on the LSPV, which had been electrically isolated at the time of the procedure. A second BA was performed at the physician's discretion. During the repeat ablation procedure, this patient underwent catheter ablation, including superior vena cava isolation and left atrial posterior wall isolation. The patient did not experience palpitations since the last procedure, and no change in the exercise capacity was observed before and after the procedure, suggesting that LSPV stenosis was clinically irrelevant. Remarkably, he remained asymptomatic for 126 months following the initial BA.

Case 5

A 52-year-old man presented with severe symptomatic LIPV stenosis 3 months after PVI. After BA, LIPV stenosis improved from severe to mild, and the patient remained asymptomatic for 7 months. During the follow-up period, no AF recurrence was observed.

Case summary

Thirteen BA procedures targeting 18 veins were performed during 60 months (range, 34–101 months) of follow-up. The details of the procedure are presented in Table 2. Three patients had complete resolution of symptoms after the first BA procedure. Four of the 5 patients had restenosis after BA, all requiring additional BA. In 2 patients, this was for symptom treatment and in the other 2 patients for asymptomatic restenosis, performed at operator's discretion. Three patients (cases 1, 2, and 4) had residual moderate or severe PVS after multiple procedures, but remained asymptomatic after more than 5 years.

The ablation points during the first session are shown in [Supplemental Figure 1](#). The ablation site for the stenosed veins were slightly inside, which might have caused PVS.

Discussion

This case series is the first to report long-term outcomes after repeat BA for symptomatic severe PVS. The main finding of this study was that BA for severe PVS was associated with a high incidence of restenosis, which is in line with previous reports; however, it was not necessarily associated with worsening of clinical symptoms. Four of the 5 patients remained asymptomatic after BA. This suggests that BA alone could maintain PV patency to the extent that it does not worsen clinical symptoms. Although stent-based approaches have shown better outcomes compared with BA, repeat BA may be considered as a treatment alternative for PVS in specific situations when stent implantation is challenging due to anatomically complex PVs or when the risk of stent-related complications is high.

Stenting has recently become the preferred procedure in patients with symptomatic PVS because it is associated with a lower incidence of restenosis and reduced need for repeat interventions compared with BA.⁴ However, the incidence of restenosis is not negligible. Fender and colleagues⁷ reported that the incidence of restenosis was similar between stenting and BA for restenosed veins after PV angioplasty. The optimal treatment strategy remains unknown for restenosed veins. Moreover, PVS after PVI often occurs in young patients.^{8,9} Thus, the benefits and risks of the lifelong necessity of administering antithrombotic or antiproliferative agents after stenting should be counterbalanced.¹⁰ Schoene and colleagues¹¹ investigated the natural PVS course after radiofrequency ablation for AF. They revealed that the number of patients with PVS-related symptoms decreased from 32% to 13%, with a spontaneous reduction in stenosis grade, over a 3.5-year follow-up. Our study revealed that repeat BA could achieve long-term PV patency to an extent that did not necessitate further interventions to resolve symptoms, despite restenosis. The compensatory process of the pulmonary circulation may also play a role

in symptom improvement. Considering that the resolution of PVS-related symptoms can be achieved spontaneously or with BA alone, stenting might be considered when refractory symptomatic PVS remains after BA. A recent study showed that angioplasty with drug-coated balloons was associated with a lower risk of restenosis compared with BA without drug delivery.¹² Further studies are needed to investigate the impact of drug-coated balloons on recurrent PVS. PVS has decreased due to the more proximal atrial side of PVI¹³; however, some cases require performing inner PV or carina ablation, which would pose a risk factor for PVS. Accordingly, exploring appropriate treatment approaches for PVS is needed.

Conclusion

BA for PVS results in a high incidence of restenosis. However, long-term symptom-free survival can be achieved with BA alone, despite angiographic restenosis. Considering the uncertainty of the optimal drug treatment and relatively high incidence of restenosis after stenting, repeat BA may be considered to treat recurrent PVS.

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Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2024.10.026>.

References

1. Raeisi-Giglou P, Wazni OM, Saliba WJ, et al. Outcomes and management of patients with severe pulmonary vein stenosis from prior atrial fibrillation ablation. *Circ Arrhythm Electrophysiol* 2018;11:e006001.
2. Fender EA, Widmer RJ, Hodge DO, et al. Severe pulmonary vein stenosis resulting from ablation for atrial fibrillation: presentation, management, and clinical outcomes. *Circulation* 2016;134:1812–1821.
3. Suntharos P, Worley SE, Liu W, Siperstein M, Prieto LR. Long-term outcome of percutaneous intervention for pulmonary vein stenosis after pulmonary vein isolation procedure. *Catheter Cardiovasc Interv* 2020;95:389–397.
4. Almakadma AH, Sarma D, Hassett L, et al. Pulmonary vein stenosis-balloon angioplasty versus stenting: a systematic review and meta-analysis. *JACC Clin Electrophysiol* 2022;8:1323–1333.
5. Li Y-J, Pan X, Wang C, He B. Stent implantation for severe pulmonary vein stenosis or occlusion secondary to atrial fibrillation ablation. *Int J Cardiol* 2020;301:85–89.
6. Calkins H, Hindricks G, Cappato R, et al. 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter and surgical ablation of atrial fibrillation: Executive summary. *Heart Rhythm* 2017;14:e445–e494.
7. Fender EA, Widmer RJ, Mahowald MK, Hodge DO, Packer DL, Holmes DR. Recurrent pulmonary vein stenosis after successful intervention: prognosis and management of restenosis. *Catheter Cardiovasc Interv* 2020;95:954–958.
8. Tokuda M, Ogawa T, Tokutake K, Yamashita S, Yoshimura M, Yamane T. Comprehensive review of pulmonary vein stenosis post-atrial fibrillation ablation: diagnosis, management, and prognosis. *Cardiovasc Interv Ther* 2024;39:412–420.
9. Yokoi K, Katsuki T, Yamaguchi T, et al. Pulmonary vein intervention for severe pulmonary vein stenosis after atrial fibrillation ablation—a retrospective cohort study. *Circ J* 2024;88:1099–1106.
10. Simard T, Sarma D, Miranda WR, et al. Pathogenesis, evaluation, and management of pulmonary vein stenosis: JACC review topic of the week. *J Am Coll Cardiol* 2023;81:2361–2373.
11. Schoene K, Sepehri Shamloo A, Sommer P, et al. Natural course of acquired pulmonary vein stenosis after radiofrequency ablation for atrial fibrillation—is routine follow-up imaging indicated or not? *J Cardiovasc Electrophysiol* 2019;30:1786–1791.
12. Denby KJ, Tereshchenko LG, Kanj M, et al. Efficacy of drug-coated balloon angioplasty in pulmonary vein stenosis or total occlusion. *JACC Clin Electrophysiol* 2024;10:1840–1847.
13. Padala SK, Ellenbogen KA. Pulmonary vein stenosis after atrial fibrillation ablation: an iatrogenic problem larger than the primary problem. *Circ Arrhythm Electrophysiol* 2018;11:e006461.