A case of balloon angioplasty guided by integrated backscatter intravascular ultrasound for the treatment of pulmonary vein stenosis caused by radiofrequency atrial fibrillation

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Introduction

In recent years, there has been an increase in the number of cases involving catheter ablation for atrial fibrillation (AF). Because of this increased incidence, there is a high risk of encountering serious complications. Pulmonary vein stenosis (PVS) is a known complication of catheter ablation for AF. Existing literature shows that the incidence of this complication is up to 31.4% at present.[1] Previous studies have reported the efficacy of catheter intervention for the treatment of PVS, including balloon angioplasty and stenting. However, in some cases, restenosis of the veins can occur following catheter intervention. Existing literature states that one of the risk factors for restenosis is the duration of time between pulmonary vein isolation (PVI) and the first angioplasty for PVS,[2] implying that the characterization of tissues in cases of PVS might change over time.

However, little is known about the tissue characteristics of PVS during catheter intervention. In this report, we describe the case of a patient in whom we performed balloon angioplasty for PVS using integrated backscatter intravascular ultrasound (IB-IVUS).

KEY TEACHING POINTS

- This is the first report of integrated backscatter intravascular ultrasound (IB-IVUS) tissue characterization during catheter intervention for pulmonary vein stenosis (PVS).
- Objective plaque characterization based on IB-IVUS for PVS seemed to be useful for estimating the efficacy of balloon angioplasty.
- IB-IVUS findings might help in determining an optimal intervention strategy for PVS.

Case report

A 65-year-old man with paroxysmal AF was referred to our center for catheter ablation. Prior to treatment, he underwent contrast-enhanced computed tomography, which revealed that the sizes of the left atrium and pulmonary veins were normal. After obtaining informed consent from the patient, we performed extensive encircling PVI.

Five months after extensive encircling PVI, the patient had gradual onset of cough with bloody sputum. Enhanced computed tomography findings led to the diagnosis of a left inferior PVS (Figure 1). To improve the patient's symptoms, we performed balloon angioplasty. Heparinized saline was infused to maintain an activated clotting time of 300–350 seconds during pulmonary vein angioplasty. Two sheaths (SL0 and Agilis, Abbott, St. Paul, MN) were inserted into the left atrium using the Brockenbrough method, and left atrial contrast was applied via the sheaths. Left atriography showed 90% stenosis of the left inferior pulmonary vein.

IB-IVUS (Navifocus, Terumo, Tokyo, Japan) was used to examine the PVS in more detail, and it revealed that the plaques had no red tissue (calcification), 0.13% ± 0.25% yellow tissue (mixed lesion), 26% ± 16% green

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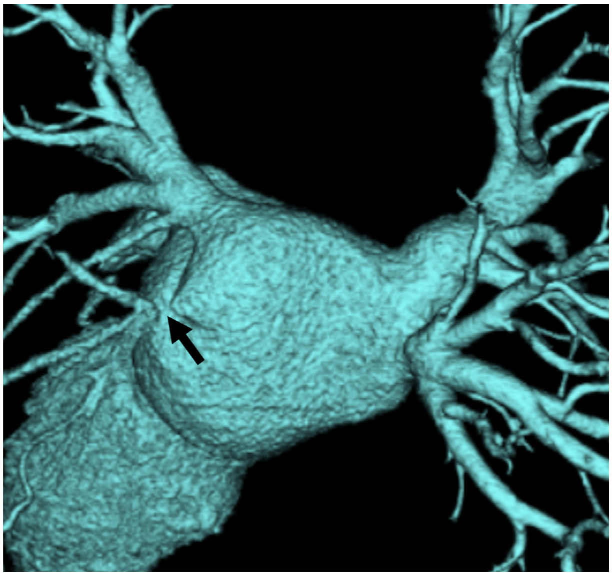

Figure 1 Contrast-enhanced computed tomography showing a left inferior pulmonary vein stenosis.

tissue (fibrous), 38% ± 6% blue tissue (lipid), and 36% ± 20% purple tissue (thrombus or intimal hyperplasia) (Figure 2). Red tissue indicates hard plaques, blue and purple tissue indicates soft plaques, and yellow and green tissue indicates intermediate plaques. According to the findings, we judged that most of the plaques in the PVS had soft tissue. We decided to perform balloon angioplasty only without stenting. We successfully performed balloon dilatation for the PVS (first balloon: 2.5 × 10 mm, Lacrosse LAXA, Goodman, Tokyo Japan; second balloon: 5.0 × 20 mm, Senri, Terumo, Tokyo, Japan). The extent of stenosis improved from 90% (severe stenosis) to 50% (intermediate stenosis). After approximately 30 minutes, the lumen diameter at the PVS site was reevaluated, and immediate recoil was not found. Ultimately, we decided not to perform stenting. The final pressure gradient across the culprit lesion was 6 mm Hg. The symptoms disappeared over the next few days, and radiography showed an improvement in the infiltrative shadow. The patient had no recurrence of symptoms over a 6-month follow-up period.

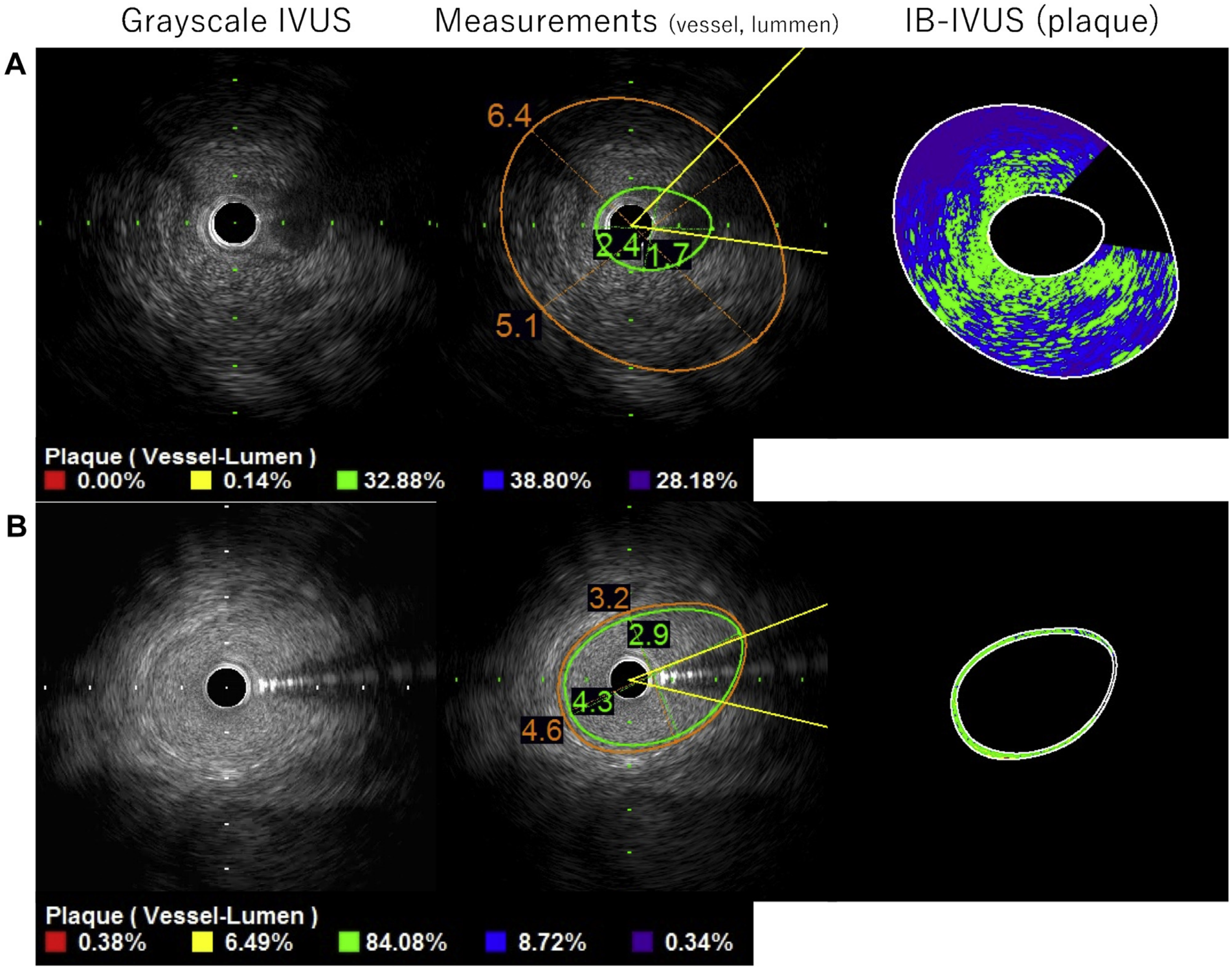

Figure 2 Integrated backscatter intravascular ultrasound (IB-IVUS) findings for the left inferior pulmonary vein stenosis (PVS) and a normal pulmonary vein. **A:** The upper figures show the segment of the PVS. The left panel shows the original IVUS finding, while the center panel shows the region of interest. The right panel shows IB-IVUS findings, which classify the plaque into 5 different colors (purple and blue: intimal hyperplasia or lipid core; green: fibrous tissue; yellow: dense fibrosis; red: calcification). The segment of the PVS shows 33% green tissue, 39% blue tissue, and 28% purple tissue. **B:** The lower figures show a nonstenotic pulmonary vein distal to the PVS, which is mostly composed of green tissue (fibrosis).

Discussion

Evidence shows that IVUS is a very useful technique to precisely evaluate lumen size, vessel size, and plaque characteristics in the coronary artery.[3] In addition, IB-IVUS can classify plaques in the coronary artery into 5 subtypes (purple: intimal hyperplasia or attenuated lipid core; blue: lipid; green: fibrous; yellow: dense fibrosis; red: calcification) by using the IB values of radiofrequency signals from the region of interest. With regard to the thrombus itself, the IB values of radiofrequency signals are lower than those of intimal hyperplasia or a lipid core; therefore, a thrombus is often identified by purple tissue on IB-IVUS.[3]

In this patient, we applied IVUS for precise balloon size and IB-IVUS for objective plaque characterization before angioplasty for the PVS. IB-IVUS revealed that the plaques had green tissue (fibrous), blue tissue (lipid), and purple tissue (thrombus). In a previous paper, Lu and colleagues[4] reported the pathology of PVS and stated that histologic examination showed an increase in elastic fibers, intimal hyperplasia, and hemosiderin-laden macrophages; the authors further stated that these features were consistent with previous pulmonary hemorrhage.[4] These plaque components appeared similar to our current IB-IVUS findings. In this case, we especially focused on plaque hardness, which increases in the order of purple, blue, green, yellow, and red by IB-IVUS color coding. Thus, balloon expansion might be effective when most plaques are composed of soft tissue, such as purple or blue tissue, whereas the risk of restenosis associated with balloon under-expansion might be increased when most plaques are composed of hard tissue, such as red or yellow tissue.

In cases of PVS, precise IVUS measurement and objective IB-IVUS data might help in determining an optimal intervention strategy for restenosis prevention. This hypothesis should be tested thoroughly in future research.

Conclusion

We describe the first application of IB-IVUS during catheter intervention for PVS and demonstrated that the application of IB-IVUS might improve the outcomes of PVS treatment.

References

1. Teunissen C, Velthuis BK, Hassink RJ, et al. Incidence of pulmonary vein stenosis after radiofrequency catheter ablation of atrial fibrillation. JACC Clin Electrophysiol 2017;3:589–598.
2. Prieto LR, Schoenhagen P, Arruda MJ, Natale A, Worley SE. Comparison of stent versus balloon angioplasty for pulmonary vein stenosis complicating pulmonary vein isolation. J Cardiovasc Electrophysiol 2008;19:673–678.
3. Kawasaki M, Takatsu H, Noda T, et al. In vivo quantitative tissue characterization of human coronary arterial plaques by use of integrated backscatter intravascular ultrasound and comparison with angioscopic findings. Circulation 2002; 105:2487–2492.
4. Lu HW, Wei P, Jiang S, et al. Pulmonary vein stenosis complicating radiofrequency catheter ablation: Five case reports and literature review. Medicine (Baltimore) 2015;94:e1346.