Percutaneous Revascularization of a Chronic Total Occlusion of the Left Lower Pulmonary Vein

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ABSTRACT: Pulmonary vein stenosis occurs in 1.3% of patients undergoing pulmonary vein isolation procedures for atrial fibrillation. Complete occlusion can occur and is often associated with symptoms including dyspnea and chest pain. Percutaneous intervention with angioplasty and stenting is frequently performed for pulmonary vein stenosis, but management of pulmonary vein occlusion remains challenging. We report the case of a 47-year-old female who presented with dyspnea and history of two previous radiofrequency ablation procedures for paroxysmal atrial fibrillation. Initial imaging with a ventilation/perfusion scan showed absent perfusion of the lower one-third of the left lung, and occlusion of the left lower pulmonary vein was confirmed by computed tomography (CT). Under sedation, with transesophageal echocardiographic and fluoroscopic guidance, the left atrium was accessed via the right femoral vein and a transseptal puncture. Initially, hydrophilic coronary guidewires were not able to cross the occlusion, but antegrade wire-escalation strategies usually reserved for coronary chronic total occlusion (CTO) cases were successful. The lesion was successfully stented, with prompt resolution of symptoms and stent patency demonstrated at follow-up.

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Pulmonary vein stenosis is a rare but important complication following catheter ablation for atrial fibrillation, occurring in up to 1.3% of patients. Symptoms of severe stenosis or occlusion can be life threatening. In most cases, percutaneous revascularization with balloon angioplasty and stenting is required, but cases requiring surgery have been reported. We present the case of a 47-year-old female with an occluded left lower pulmonary vein, treated percutaneously using advanced antegrade chronic total occlusion (CTO) techniques.

Case Report

A 47-year-old female presented to the emergency department with severe dyspnea and pleuritic chest pain. She had a history of paroxysmal atrial fibrillation, treated initially with radiofrequency catheter ablation 3 years prior and a repeat procedure for recurrence 2 years prior. Other comorbidities included hypertrophic cardiomyopathy complicated by ventricular fibrillation and AICD implantation.

The patient reported progressive dyspnea over 6 months that had occurred at rest prior to the intervention (New York Heart Association class 4). There was associated left lateral pleuritic chest pain, but no cough, fever, or hemoptysis. The patient denied palpitations or syncope, and interrogation of the AICD was unremarkable. Clinical examination revealed no fever, normal pulse and blood pressure, but reduced oxygen saturation (SpO2 93% on air). Examination of the chest noted dullness to percussion at the base with absent air entry on auscultation.

Chest x-ray showed obscuration of the left hemidiaphragm and a subsequent ventilation/perfusion (VQ) scan demonstrated reduced left lung perfusion, with the left lower third accounting for <1% of total lung perfusion (Figure 1). Computed tomography pulmonary venogram showed occlusion of the left lower pulmonary vein (LLPV), with a nub present at the ostium (Figure 2).

Under sedation, and with transesophageal echocardiographic (TEE) and fluoroscopic guidance, a Brockenbrough needle (BRK; St Jude Medical) was used to cross the interatrial septum. An SL1 sheath was then advanced and directed, and left in the left atrium. A left atrial angiogram was performed, identifying the nub at the ostium of the LLPV (Figure 3A). A 5 Fr MPA diagnostic catheter was then inserted into the sheath and a Hi-Torque Whisper coronary guidewire (Abbott Vascular) was used to penetrate the pulmonary vein occlusion, but was unsuccessful (Figure 3B).

Next, a Fielder XT guidewire (Asahi Intecc) was chosen in an attempt to access potential microchannels. This has a hydrophilic polymer coating, as well as a tapered tip, but was also unsuccessful (Figure 3C). Finally, a Miracle 3 guidewire (Asahi Intecc), which is usually reserved for coronary CTO cases, was able to cross the occlusion (Figure 3D).

The Miracle 3 guidewire was carefully advanced into the peripheral vein under fluoroscopic and TEE guidance and position was confirmed with contrast injection through the 5 Fr MPA catheter. A 1.5 x 15 mm Apex monorail balloon (Boston Scientific) was inflated to 20 atm for 45 s at the occlusion. This did not completely restore antegrade flow. The MPA catheter was advanced into the distal vein, allowing exchange for an 0.035" Amplatz wire (Cook Medical) and dilation with larger balloons (up to 5.0 mm) before a 7.0 x 19 mm Omnilink Elite stent (Abbott Vascular) was deployed at 18 atm for 120 s (Figure 4A). Postdilation was performed with a 9.0 x 20 mm balloon, with an excellent angiographic result (Figure 4B).

The patient reported dramatic improvement in her breathing, and was asymptomatic at 1- and 6-month follow-up exams. Stent patency was confirmed at 1 month by TEE, with flow in the left lower pulmonary vein (Figure 5) and at 9 months by computed tomography.
Discussion

Pulmonary vein stenosis (PVS) is an important complication of radiofrequency ablation (RFA) for atrial fibrillation (AF), with an estimated incidence of 1.3%. Pulmonary vein occlusion is more rare, with only 18 cases reported in a large series of 1780 AF ablation cases (0.8%). Prevalence of this complication has decreased with improvements in catheter ablation techniques (less radiofrequency energy delivered, avoidance of the orifice of the pulmonary veins) and increased operator experience. Identified risk factors for PVS include repeat catheter ablation procedures and low operator experience. Progression of stenosis is unpredictable, although one series reported median symptom onset of 103 ± 100 days from the index procedure. This case represents late symptom onset with progression to dyspnea at rest likely related to complete vein occlusion.

Symptoms related to complete pulmonary vein occlusion include dyspnea, cough, pleuritic chest pain, and hemoptysis. Symptoms are variable, and while some are asymptomatic, those with more than one vein occluded are more likely to have severe symptoms. In this case, severe dyspnea and pleuritic chest pain were associated with progressive stenosis and occlusion of one pulmonary vein, likely related to the large matched ventilation and perfusion defect noted on the VQ scan.

Multiple imaging modalities are available when considering pulmonary vein stenosis or occlusion. VQ imaging is very useful, with marked perfusion abnormalities in the distribution of affected veins. As expected, the VQ was grossly abnormal in the case reported here. CT angiography and magnetic resonance (MR) angiography are the established gold standard, providing three-dimensional images of the pulmonary veins and left atrium. However, pulmonary veins that appear occluded on CT imaging may in fact be patent at angiography. The remaining nub at the ostium of the pulmonary vein is a useful landmark, and may be correlated between CT and angiography. In the absence of a nub or dimple, a selective pulmonary artery angiogram may help identify the location of the occluded vein, particularly if the occlusion length is short.

TEE offers real-time imaging via flow velocities and turbulent blood flow with increased aliasing on color-flow examination, although the inferior veins can be difficult to visualize and occluded veins may be missed. TEE also allows real-time identification of potential complications such as pericardial tamponade or perforation. Conventional pulmonary venography can be performed at the time of repeat ablation procedures, but is unnecessarily invasive as a diagnostic tool.

Percutaneous intervention for PVS with angioplasty and stenting is able to reduce stenosis, improve flow velocities, and rapidly reduce symptoms. Stenting, especially with large stents, is more effective than balloon angioplasty. Vessel sizing can be difficult, with dilation to 10 mm at 10-14 atm generally recommended. Unfortunately, restenosis is common, occurring in

Figure 1. Chest x-ray (left) showing obscuration of the left hemidiaphragm, suggestive of collapse, and ventilation/perfusion scan (right) with absent perfusion of the left lower one-third.

Figure 2. Computed tomography pulmonary venogram demonstrating occlusion of the left lower pulmonary vein (arrow).
Pulmonary Vein CTO Intervention

up to 47% of cases, and occurs as both in-stent restenosis and in-segment restenosis, proximal or distal to the stent.

Management of occlusion is more difficult. In a series of 19 patients published by Qureshi et al., intervention was attempted on only 1 out of 5 patients with occluded veins, and was unsuccessful. Di Biase reported attempted cannulation of occluded pulmonary veins in 17 patients with failure in 2 patients. Levy et al. published a case of successful revascularization of a flush occluded left lower pulmonary vein using a single “stiff 0.014” guidewire” in a patient 5 months after catheter ablation. Treatment with lobectomy has been reported in a case of recurrent stenosis with occlusion, and surgical repair with pulmonary homograft tissue may be considered in extreme cases.

Serious complications have been reported, including intraprocedural hemoptysis requiring intubation, pulmonary hemorrhage, and pulmonary vein tear requiring urgent surgery. Pulmonary vein dissection has been reported with a 12 mm balloon.

In this case, advancements in techniques designed for coronary artery CTO have been translated to treat an occluded pulmonary vein. The guidewire escalation strategy adopted here initially used soft, hydrophilic guidewires with minimal chance of vessel dissection or perforation. Failure of these wires to cross the occlusion necessitated adoption of a stiffer wire, with a higher tip-load and penetrating force. This was successful and allowed step-wise dilation of the vein and eventual stenting, with an excellent clinical result.

Figure 3. Left atrial angiogram shows the left lower pulmonary vein is occluded (A). Initially, a Hi-Torque Whisper coronary guidewire was used, but was unable to cross the lesion (B). Next, a Fielder XT guidewire was chosen, without success (C). Finally, a Miracle 3 guidewire, usually reserved for coronary chronic total occlusion cases, was able to cross the occlusion (D).

Vol. 26, No. 4, April 2014 173
Routine follow-up involves clinical review and imaging performed early after the procedure (24-48 hours) to exclude complications. Stent patency should be assessed at 1-3 months, with clinical follow-up thereafter. In this case, both CT angiography and TEE demonstrated stent patency. In cases where restenosis is suspected, repeat angiography is required.

**Conclusion**

We report successful percutaneous revascularization of a chronic total occlusion of a pulmonary vein in a patient who underwent radiofrequency ablation for AF 2 years prior. Pulmonary vein occlusion is a rare but serious complication, which may be avoided with improved catheter ablation techniques. For this highly symptomatic patient, a novel approach adopting techniques learned from coronary artery CTO procedures achieved safe recanalization and stenting. This procedure can be considered by experienced operators as an alternative to open heart surgery.

**Figure 4.** A 7.0 x 19 mm Omnilink Elite stent (Abbott Vascular) was deployed at 18 atm for 120 seconds (A), with an excellent angiographic result (B).

**Figure 5.** Flow within the left lower pulmonary vein was documented by PW Doppler transesophageal echocardiogram at 1 month.

**References**