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Dual-energy computed tomography-angiography in the evaluation and management of significant multiple pulmonary vein stenoses following atrial fibrillation ablation

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Abstract

A 58-year-old male patient with multi-vessel pulmonary vein (PV) stenosis following atrial fibrillation ablation was referred to a specialized pulmonary hypertension clinic. Chest dual-energy computed tomography (CT)-angiography allowed precise diagnosis of two PVs occlusion and three PVs significant stenosis. Iodine maps showed perfusion deficiency and its value for each stenosis, determining the sequence of multiple PV interventions. We suggest iodine CT mapping is a useful tool in the definition of PV stenosis severity and planning staged angioplasty.

Keywords

radiofrequency catheter ablation, stent implantation, pulmonary hypertension, iodine maps

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Case description

A 58-year-old man was referred to a pulmonary hypertension clinic with a progressive history of heart failure (III functional class NYHA) with orthopnea, peripheral edema, and the presence of severe pulmonary hypertension (PH) according to a transthoracic echocardiographic evaluation (TTE). The history included radiofrequency catheter ablation of atrial fibrillation incorporating pulmonary vein (PV) isolation 10 months ago in a different hospital. One month after ablation the patient reported shortness of breath, which was explained by the recurrence of persistent atrial fibrillation. Contrast-enhanced chest CT was performed at a local hospital and revealed lung interstitial changes and lymphadenopathy and signs of PH. There was no evidence of both acute and chronic pulmonary embolism (PE).

At admission, TTE showed left atrial dilatation (left atrial volume index 42 ml/m^2), preserved right ventricle size and function (4-chamber basal size 38 mm; tricuspid annular plane systolic excursion 1.7 cm), and preserved left ventricle systolic function (left ventricular ejection fraction 55%). The pulmonary artery was dilated (26 mm), and the estimated pulmonary artery systolic pressure was 70 mmHg.

Chest dual-energy CT-angiography (tube A—140 kV, 47 mAs; tube B—80 kV 80, 235 mAs) was performed and revealed multiple PV stenosis (Fig. 1). A detailed analysis demonstrated the following PV inflow variant: R 4b and L 2a in Marom classification.[1] There are four separate ostia of the right PVs (right upper lobe pulmonary vein (RUL), right middle lobe pulmonary vein (RML), superior segment right lower lobe pulmonary vein (SSRLL), right lower lobe pulmonary vein (RLL); two separate left PV ostia (left upper lobe pulmonary vein (LUL), and left lower lobe pulmonary vein (LLL)). LLL pulmonary vein was present as a confluence of superior segment left lower lobe (SSLLL) and basal pyramid veins (5 mm distal to the PV ostium). Three right

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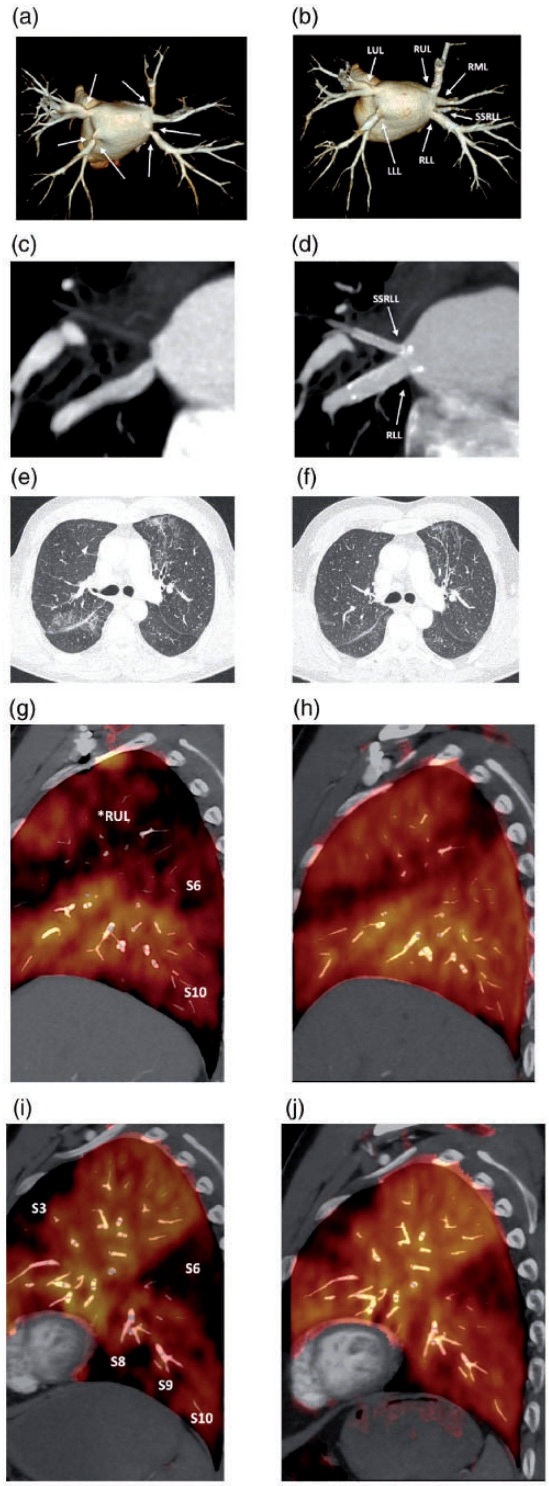

Fig. 1. CT data before and after percutaneous PV angioplasty. Left panels (a, c, e, g, i): dual-energy CT-visualization at admission. Right panels (b, d, f, h, j): dual-energy CT-visualization after PV angioplasty with stenting. (a) CT VRT reconstruction: multiple PV stenoses shown by arrows. (b) CT VRT reconstruction after PV angioplasty: PVs shown by arrows (RUL: right upper lobe pulmonary vein; RML: right middle lobe pulmonary vein; SSRLL: superior segment right lower lobe pulmonary vein; RLL: right lower lobe pulmonary vein; LUL: left upper lobe pulmonary vein; LLL: lower lobe pulmonary vein). (c) CT frontal (continued)

PVs were stenotic: there was a sub-occlusion of RUL, sub-occlusion of SSRLL, 70% stenosis of RLL. Two left PVs were stenotic: 35% stenosis of LUL; total occlusion of SSLLL, and 75% stenosis of the basal pyramid PV branch. Dual-energy CT iodine maps showed the following "perfusion" defects: a large irregular defect in the right upper lobe, segmental defects in the right S6, in the left S3, S6, S8, subsegmental in the left and right S10. A moderate "hyperperfusion" of the right middle lobe was determined.

PV angioplasty was indicated, and the heart team suggested right heart catheterization (RHC) with percutaneous PV ballooning and stenting as the first-line approach.

Under light sedation, right femoral cannulation was performed using the Seldinger technique. RHC defined severe postcapillary PH: mean pulmonary artery pressure (PAP) 30 mmHg, pulmonary artery wedge pressure (PAWP) 29 mmHg. An antegrade transseptal access was performed using a Brokenbrough needle, and a steerable 8F transseptal sheath (Direx, Boston Scientific, USA) was introduced into the left atrium. Selective PV angiography using a 6F multipurpose catheter (Cordis, Johnson and Johnson, USA) confirmed the presence of two PV occlusion (SSRLL and SSLLL brunch), sub-occlusion of RUL, RLL and stenosis of LUL about 50%.

Considering the number of severely stenotic PVs, a decision on a two-stage angioplasty approach was made. Since the right lung was more "hypoperfused" according to the CT iodine maps, the right PVs were targeted first. The right upper lobe PV was dilated and stented with the balloon-expandable stent Renal Dynamic 7 × 19 mm (Biotronik, Germany). The lower lobe PV was stented with the Epic stent 10 × 30 mm (Boston Scientific). Cannulation of SSRLL was unsuccessful during the first procedure. A slight decrease in PAP was noted: from 51/20/30 to 45/18/27 mm Hg. The patient was discharged with clinical improvement on triple antithrombotic therapy.

A second angioplasty was performed after one month. The previously stented PVs showed no restenosis. A second successful SSRLL cannulation attempt was performed, and the Promus 3.5 × 24 (Boston Scientific) stent was implanted. A Dynamic Renal 6 × 15 stent (Biotronik) was implanted into LLL. Balloon angioplasty of LUL was performed. Multiple attempts for cannulation of SSLLL brunch were unsuccessful. The control RHC showed reduction of mean PAP to 21 mm Hg and PAWP to 17 mm Hg.

Fig. 1. Continued
MPR-reconstruction: SSRLL sub-occlusion and RLL stenosis. (d) The SSRLL and RLL after stenting. (e) Baseline interstitial pulmonary changes: interlobular septal thickening and ground glass opacities due to edema; (f) partial regression of the interstitial changes after PV angioplasty. (g) and (i) Baseline right and left lung iodine maps (sagittal reconstruction), correspondingly: *RUL: right upper lobe, S3, S6, S8, S9, S10: pulmonary segments. (h) and (j) Right and left lung iodine maps (sagittal reconstruction) after PV angioplasty demonstrating a significant perfusion improvement.

There were no complications during and following the interventions.

Control CT-angiography at discharge demonstrated restored lumen of all PVs with angioplasty, and slight residual narrowing of LUL. Triple antithrombotic therapy with aspirin, clopidogrel, and dabigatran 150 mg BID was prescribed for one month and then changed to a combination of dabigatran and clopidogrel. The patient significantly improved and had no dyspnea at three months of follow-up.

Discussion

We report on the use of dual-energy CT iodine maps in the diagnosis of the functional severity of acquired multi-vessel PV stenosis, which is a rare complication of atrial fibrillation ablation occurring in less than 1% of cases.[2,3] The most common symptom is shortness of breath, and its severity depends on the number of affected veins.[4,5] PV stenosis is an example of postcapillary PH, which requires differentiation with PE and other PH causes. Perfusion scintigraphy, the most common screening tool for PE, has a low specificity for differential diagnosis.[6] We suggest that dual-energy CT iodine maps allow estimating the significance of vascular lesion in the case of acquired PV stenosis and help to schedule a staged approach in patients with multiple stenoses. Perfusion redistribution due to PV stenosis is an important compensatory mechanism that leads to a decrease in blood flow in those parts of the lungs from which the venous outflow is disrupted. This mechanism causes specific perfusion defects on iodine maps.[6,7]

There are several interventional options for PV stenosis treatment, and the management of multivascular and bifurcation PV lesions is particularly difficult. Previous reports have shown the advantage of peripheral larger stents over balloon angioplasty and smaller size drug-eluting coronary stents for patients with PV stenosis following atrial fibrillation ablation.[8–10]

Conclusion

We suggest that in patients with multiple PV stenosis a staged approach to angioplasty is feasible and safe. Dual-energy CT-angiography allows determining the contribution of each stenotic PV to pulmonary perfusion deficiency.

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Authors' contributions

All listed authors have contributed to and approve the manuscript.

Consent to publish case report

All listed authors consent to publication.

Conflict of interest

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