Pulmonary veins CT: Imaging techniques, report and common ablation complications

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Learning objectives

We review the technique of multidetector row computed tomography (CT) with/without ECG gating.

We describe the relevant findings to making a report prior to ablation of pulmonary veins and the potential complications of percutaneous ablation.

Background

Ablation of the distal pulmonary veins and posterior left atrium is increasingly being used to treat recurrent or refractory atrial fibrillation (AF) that resists pharmacologic therapy or cardioversion.

The goal of ablation is to remove the electrical activity in the pulmonary veins (focal ablation) or prevent such activity from spreading into the left atrium (pulmonary vein isolation).

Patients with refractory AF will be treated by radiofrequency ablation or cryoablation balloon, procedure success is directly proportional to the knowledge of the complex three-dimensional anatomy of the pulmonary veins and the posterior left atrium.

CT of the pulmonary veins and left atrium provides the necessary anatomic information for successful ablation.

Radiologists must not only understand these techniques but must also be able to make a report with the useful data prior the ablation and know the possible complications.

Imaging findings OR Procedure details

CT Technique

- We perform a thoracic CT limited to the paracardiac region, to assess the morphology of the left atrium and pulmonary veins. Fig. 1 on page 4
• 90 CC of contrast at concentration of 370 mg/ml are administered through a peripheral vein with a high flow (4-5 ml/sec). The ROI is placed in the left atrium with a threshold of 140 UH using a bolus tracking technique. Fig. 2 on page 5

*When patients conditions are optimal (Normal sinus rythm or AF with a stable ventricular response and a heart rate of less than 70-80 beats per minute) we perform the CT with ECG gating.*

**Post processed**

• Detailed images using reconstructions in three dimensions (3D) and virtual endoscopy in the workstation analysis.
• 3D images should include the entire left atrium and pulmonary veins, removing the remaining structures. Fig. 3 on page 6
• Endoscopic views of the ostia are obtained of both left and right pulmonary veins. Fig. 4 on page 7
• MIP and 3D volume reconstruction give us more information to guide the clinician and demonstrate normal anatomical findings and its variants. Fig. 5 on page 8 and Fig. 6 on page 9

**Radiological Report**

It is necessary to outline the following measures and characteristics of left atrium-pulmonary vein complex in the radiology report. Fig. 7 on page 10

1. Pulmonary vein anatomical description
   • Pulmonary veins reach the left atrium by its rear wall and each has its own input ostia through four independent holes
   • This anatomical configuration occurs in 70% of the general population. Fig. 8 on page 11

2. Anatomic variants. The most common anatomic variants are:
   • Common venous trunks that form between the veins of the upper and lower lobes and enter the left atrium through a common ostia.
   • Accessory pulmonary veins graining segments independently. Fig. 9 on page 11 and Fig. 10 on page 12

3. Ostium diameter of each of the pulmonary veins. Fig. 11 on page 13

4. Size and morphology of the left atrium: diameter, area and volume. Fig. 12 on page 14
5. Size and morphology of the left atrial appendage. Fig. 13 on page 15

Complications during and after procedure

- Complications secondary to this technique may manifest acutely in the electrophysiology, subacute or late. Fig. 14 on page 16
- They are usually related to scarring and stenosis in the pulmonary veins, depending on the severity, can cause venous infarction or venous congestion (due to the impossibility of venous return in the corresponding segment or lobe lung).
- The left superior pulmonary vein is the most commonly affected.
- The definitive diagnosis is made by angio-CT, where affected vein area and secondary pulmonary complications (pleural effusion, pericardial effusion, stroke, infection..) are identified.

All these complications, although rare, should be included in the differential diagnosis when unexplained symptoms appear in patients who have undergone pulmonary vein ablation. Fig. 15 on page 16, Fig. 16 on page 17 and Fig. 17 on page 18

Treatment of pulmonary vein occlusion

The therapeutic option in these patients is balloon angioplasty with stent. Fig. 18 on page 19 and Fig. 19 on page 19

Images for this section:
**Fig. 1:** We perform a thoracic CT limited to the paracardiac region, to assess the morphology of the left atrium and pulmonary veins.
**Fig. 2:** The ROI is placed in the left atrium with a threshold of 140 UH using a Bolus-tracking technique.
**Fig. 3:** 3D images should include the entire left atrium and pulmonary veins, removing the remaining structures.
Fig. 4: Endoscopic views of the ostia are obtained of both left and right pulmonary veins.
**Fig. 5:** MIP reconstruction of pulmonary veins give us more information to guide the clinician and demonstrate normal anatomical findings and its variants.
Fig. 6: 3D reconstruction of pulmonary veins give us more information to guide the clinician and demonstrate normal anatomical findings and its variants.
Fig. 7: Radiological Report.

Fig. 8: 3D and MIP reconstruction of atrium and pulmonary veins, normal anatomy.
**Fig. 9:** 3D reconstruction of the pulmonary veins: three ostia with combined output of the left vein (blue arrow)
Fig. 10: 3D reconstructions of the pulmonary veins: Five ostia of pulmonary veins with independent origin of the middle lobe vein, although adjacent to the ostia of the vein of the upper lobe.
**Fig. 11:** Oblique reconstructions to get the diameter of each pulmonary vein ostia.
Fig. 12: Size and morphology of the left atrium: diameter, area and volume.
**Fig. 13:** Size and morphology of the left atrial appendage.

Complications during ablation

- Endocardial charring
- Dissection of the pulmonary vein
- Atrial or pulmonary vein Drilling
- Bradyarrhythmias, including asystole (due to the fibers of the vagus nerve that are located within the walls of the pulmonary veins)
- Gastric hypomotility (secondary to injury of the vagus nerve to periesophageal level)

Late complications

- Pleural or pericardial effusion, hemopericardio, hemothorax
- Transient atrial septal defects
- Thrombosis and pulmonary vein stenosis can lead to venous infarction and has been associated with fibrosing mediastinitis, the pulmonary veno-occlusive disease, including development of severe pulmonary arterial hypertension
- Embolism: ACV
- Phrenic nerve injury

**Fig. 14:** Complications during and after procedure.
**Fig. 15:** Patients with a history of focal pulmonary vein ablation, attended to the emergency room with chest pain, cough and hemoptisis. Angio-CT of pulmonary arteries, soft tissue window, axial and sagittal oblique MIP reconstruction: lack of opacification of the left superior pulmonary vein (LSPV) with permeability of the remaining vessels. Axial lung window: multiple poorly defined infiltrates in the left upper lobe with peripheral ground glass opacity and septal thickening.
Fig. 16: Patient with a history of pulmonary vein ablation for AF consulting for hemoptysis. Angio-CT of pulmonary arteries axial and coronal MIP reconstruction: Occlusion of the left superior pulmonary vein (yellow arrows) and anterior branch of the left inferior pulmonary vein (blue arrows).
**Fig. 17:** Patient with a history of pulmonary vein isolation with cryoablation, with chest pain and dyspnea. Angio-CT of pulmonary arteries soft tissue window, MPR, MIP reconstructions and lung window: no filling of the left inferior pulmonary vein (yellow arrow). It is associated with small left pleural effusion (blue arrow) ground glass and septal thickening predominantly in left lower lobe.

**Fig. 18:** Stent in the left pulmonary vein thrombosis secondary to complicated radiofrequency ablation. Left hemopneumothorax (blue arrow). Permeable stent (yellow arrows)
**Fig. 19:** Sclerosis chronic occlusion of the left superior pulmonary vein, permeable small collateral vessels that drain primarily lingula, which join at the ostia of the left superior pulmonary vein in which the stent is observed.
Conclusion

- Percutaneous ablation of the distal pulmonary veins and posterior left atrium is increasingly being used to treat recurrent or refractory atrial fibrillation that resist pharmacologic therapy or cardioversion.

- Multidetector row CT, preferably with ECG gating, of the left atrium and pulmonary veins provides the intra- and extraatrial anatomic information necessary for successful radiofrequency ablation.

- Radiologists should be familiar with the normal appearances of Pulmonary veins and complications encountered during and after the procedure.

References

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Personal Information

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Images for this section:

Fig. 20

Fig. 21