Case 6199

Evaluation of pulmonary vein anatomy with magnetic resonance angiography
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Section: Cardiovascular
Case Type: Anatomy and Functional Imaging
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Patient: 58 years, female

Clinical History:
A 58-year-old woman with chronic drug-resistant atrial fibrillation (AF) was referred to our centre for planning of transcatheter radiofrequency AF ablation.

Imaging Findings:
The patient underwent transesophageal echocardiography (TEE), which excluded atrial thrombosis (a major exclusion criterion for transcatheter AF ablation). Subsequently, on the same day, a magnetic resonance angiography (MRA) examination of the left atrium (LA) and the pulmonary veins (PV) was performed after administration of 20cc of gadobenate dimeglumine by using a time-resolved sequence (TRICKS: Time Resolved Imaging of Contrast KineticS) with a temporal resolution of 3.5 sec per frame. Maximum intensity projection (MIP) and volume rendering (VR) reconstructed images showed a right middle PV draining independently into the LA, while the ostia of the right superior and inferior PV, as well as those of the left superior and inferior PV, were normal (Fig. 1). The following day transcatheter AF ablation was successfully performed. Six months after the procedure, the patient still has sinus rhythm without taking any antiarrhythmic drug.

Discussion:
The normal anatomy of the venous drainage to the LA is represented by two right PV (superior, RSPV; and inferior, RIPV) and two left PV (superior, LSPV; and inferior, LIPV), each entering the LA with a separate ostium (Fig. 2). Anatomic variants are frequent and most typically involve the right PV (32% of cases); among those, the most common variation is independent drainage of one of more middle PV in the LA, which has been observed in 26% of patients. A right middle PV, either draining into the LA with a separate ostium (as shown in our case) or joining the RSPV and the RIPV with a common ostium, occurs in 24% of individuals. Other patterns include a right middle PV having a common ostium with the RIPV (3%) (Fig. 3), and two right middle PV draining separately into the LA (2%) (Fig. 4). More rarely (1%), five right PV drain separately into the LA. PV variations on the left side are less common (14%) than those on the right side, the most frequent one being a single ostium of the LSPV and the LIPV (10%) (Fig. 5). Another variant (4%) is represented by two left PV joining into a common trunk (Fig. 6). AF is the most common arrhythmic disorder and is characterized by rapid and uncoordinated atrial electric activity with an irregular ventricular response, leading to decreased cardiac output and higher risk of atrial embolism. In more than 90% of cases, AF is initiated by foci of abnormal electrical activity located in sleeves of atrial myocardium extending into the PV, which form the pathophysiological basis for transcatheter AF ablation. With this technique, the electrical pathways connecting the PV arrhythmic foci to the atrium are interrupted by delivering energy (such as radiofrequency energy) close to the PV ostia. Computed tomography angiography (CTA) and MRA are currently used for anatomic depiction of the LA and the PV ostia for pre-procedural planning of transcatheter ablation, as well
as for post-treatment assessment of PV size in case PV stenosis (a potential complication of radiofrequency AF ablation) is to be excluded. For such applications, CTA and MRA are superior to conventional angiography in that they allow to obtain three-dimensional images of the LA and the PV through post-processing algorithms. Furthermore, CTA or MRA data can be merged with intraprocedurally-achieved electrophysiological maps by means of dedicated software, thus providing an anatomical reference for accurate catheter delivery of radiofrequency energy and reducing fluoroscopy times significantly. Although CTA may also be performed on claustrophobic or pacemaker-carrying patients and can have higher spatial resolution than MRA, this latter can yield comparable diagnostic results with the advantages of no exposure to ionizing radiation and iodinated contrast material.

**Differential Diagnosis List:** Right middle PV entering the LA with a separate ostium.

**Final Diagnosis:** Right middle PV entering the LA with a separate ostium.

**References:**


Figure 1

**Description:** Fig. 1a. Axial MIP image showing a right middle PV (red arrow) draining independently into the LA. The ostia of the RSPV and the RIPV are normal. **Origin:**

**Description:** Fig. 1b. Coronal MIP image showing the right middle PV draining independently into the LA, with normal ostia and number of the other PV. **Origin:**
**Description:** Fig. 1c. VR image showing the right middle PV draining independently into the LA. The ostia of the RSPV and the RIPV are normal. **Origin:**

**Description:** Fig. 1d. VR image showing normal ostia and number of the left PV. **Origin:**
**Figure 2**

*a* Fig. 2a. MIP image showing the normal PV anatomy. 1=RSPV; 2=RIPV; 3=LSPV; 4=LIPV. *Origin:*

*b* Fig. 2b. Coronal MIP image showing the normal anatomy of the PV with their distribution to the lung parenchyma. *Origin:*
Description: Fig. 2c. VR image showing the normal PV anatomy. Origin:

Description: Fig. 2d. VR image showing the normal PV anatomy. Origin:
**Figure 3**

**a**

*Description:* *Fig. 3a.* Coronal MIP image showing a right middle PV having a common ostium with the RIPV. The left PV are normal. *Origin:*

**b**

*Description:* *Fig. 3b.* Axial oblique MIP image showing a right middle PV having a common ostium with the RIPV. The left PV are normal. *Origin:*
**Description:** Fig. 3c. VR image showing a right middle PV having a common ostium with the RIPV. **Origin:**

**Description:** Fig. 3d. VR image showing a right middle PV having a common ostium with the RIPV. The left PV are normal. **Origin:**
Description: Fig. 4a. Coronal MIP image showing two right middle PV draining separately into the LA. The left PV are normal. Origin:

Description: Fig. 4b. Axial MIP image showing two right middle PV draining separately into the LA. Origin:
**Description:** Fig. 4c. VR image showing two right middle PV draining separately into the LA.

**Origin:**

**Description:** Fig. 4d. VR image showing two right middle PV draining separately into the LA.

**Origin:**
Description: <b>Fig. 4e.</b> VR image showing normal left PV. Origin:
Description: Fig. 5a. MIP image showing the LSPV and the LIPV reaching the LA with one common ostium. Origin:
**Description:** Fig. 5b. MIP image showing normal ostia of the right PV. **Origin:**

**Description:** Fig. 5c. VR image showing the LSPV and the LIPV reaching the LA with one common ostium. **Origin:**
Description: Fig. 5d. VR image showing normal ostia of the right PV. Origin:
Figure 6

a

Description: Fig. 6a. Coronal MIP image showing the LSPV and the LIPV joining into a common trunk. The right PV are normal. Origin:

b

Description: Fig. 6b. Axial oblique MIP image showing the LSPV and the LIPV joining into a common trunk. The right PV are normal. Origin:
**Description:** Fig. 6c. VR image showing the LSPV and the LIPV joining into a common trunk. The right PV are normal. **Origin:**

**Description:** Fig. 6d. VR image showing the LSPV and the LIPV joining into a common trunk. **Origin:**
Description: Fig. 6e. VR image showing the LSPV and the LIPV joining into a common trunk. The right PV are normal. Origin: