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Transaortic pulmonary vein isolation in the presence of situs inversus and total venous anomaly; technical capabilities for 3D reconstruction and considerations of adequate choice of ablation catheters

1. Introduction

Dextrocardia and situs inversus is a very rare anatomical variant. Even more seldom is the co-occurrence with total venous anomaly and absence of a usual Inferior Vena Cava (IVC) draining into the right atrium cranially. [1,2]

The Trans-Septal Puncture (TSP) through the femoral vein in patients with situs inversus has been reported for PVI. Likewise, the retrograde PVI using the magnetic navigation system in the cases of venous anomaly has been described.

A patient with the above mentioned complete anatomical anomaly presented in our hospital for PVI due to highly symptomatic atrial fibrillation (AF). We performed the procedure via the retrograde approach by a 3D mapping system (Ensite NavX precision), 20 polar diagnostic catheter and two different ablation catheters.

2. Patient history

A 51-year-old female with dextrocardia and situs inversus presented with highly symptomatic paroxysmal atrial fibrillation episodes lasting for hours for the past few months under Metoprolol 47,5 mg, bid and Flecainide 100 mg bid.

The patient also underwent DDD-Pacemaker implantation due to Sick Sinus Syndrome in 2012 at an external hospital. Transthoracic echocardiography revealed a normal left ventricular function with concentric left ventricular hypertrophy, normal left atrial diameter and a left ventricular ejection fraction of 60%.

She was referred for catheter ablation. However, the usual TSP approach for the left atrium through femoral vein was not available because the computed tomography (and 3D-CT-reconstruction) revealed that the inferior vena cava was connected to the left brachiocephalic vein and drained cranially into the right atrium through the superior vena cava.

3. Alternative approaches for PVI

Kato et al. reported the technic for *trans*-septal puncture and catheter ablation via the superior vena cava for atrial fibrillation in a patient with poly-splenia syndrome and interruption of the inferior vena cava.[3] They performed the *trans*-septal puncture through the right jugular vein using a manually curved Brockenbrough needle and intracardiac echocardiographic guidance accomplishing pulmonary vein isolation using the deflectable guiding sheath and a contact force-sensing ablation catheter. Their method has a few advantages compared to *trans*-aortic pulmonary vein isolation. For example, they could confirm the complete pulmonary vein isolation using a ring catheter which was introduced through the *trans*-septal sheath. However, this technique has not been reported for patients with the dextrocardia. Additionally, the superior vena cava approach was rather difficult in our patient. From the left side, the jugular approach was limited due to the presence of two implanted pacemaker electrodes. From the right side the venous anomaly with persistent right superior vena cava draining into the right atrium caudally would have required bending of the transseptal needle with more than 180° to perform the TSP, which would have been beyond the elasticity of the vessels and the needle material.

Also a surgical epicardial approach as possible alternative for PVI had to be considered, specially taking into consideration epicardial cryoablation with predesigned forms. However, in this young patient the situs inversus and the total venous anomaly were also combined with an atypical origin of the pulmonary veins which would have made a surgical ablation even more challenging.

In patients with congenital heart disease an alternative access to the right atrium via the *trans*-hepatic vein was described for both pacemaker implantation and electrophysiology procedures. After co-consideration of the CT of our patient with our radiologists, this approach was esteemed risky with regard to the narrow caliber of the hepatic vessels. Hence, our interventional radiologists discouraged this approach.

Recently Okajima et al. reported the technique of *trans*-aortic pulmonary vein isolation using the magnetic navigation system in a patient with dextrocardia, situs inversus and inferior vena cava continuity with the azygous vein.[4] Considering our case, with the presence of the pacemaker (which was not MRI compatible) and also looking at the lack of a magnetic navigation system in our hospital this approach was ruled out much earlier.

Taking into consideration these thoughts and discussions, we esteemed the retrograde approach the optimal procedural way for curative therapy of this patient.

4. Retrograde PVI

After the informed consent of the patient was obtained, we attempted pulmonary vein isolation through the retrograde *trans*-aortic approach using NavX precision® for the guidance in addition to the 3D Model of the left atrium and pulmonary veins anatomy obtained from the pre-interventional CT-Imaging (Fig. 1A–G).

The CS catheter was introduced via the left femoral vein and was positioned in the coronary sinus through the inferior vena cava which (with a big arch) drained cranially into the right atrium.

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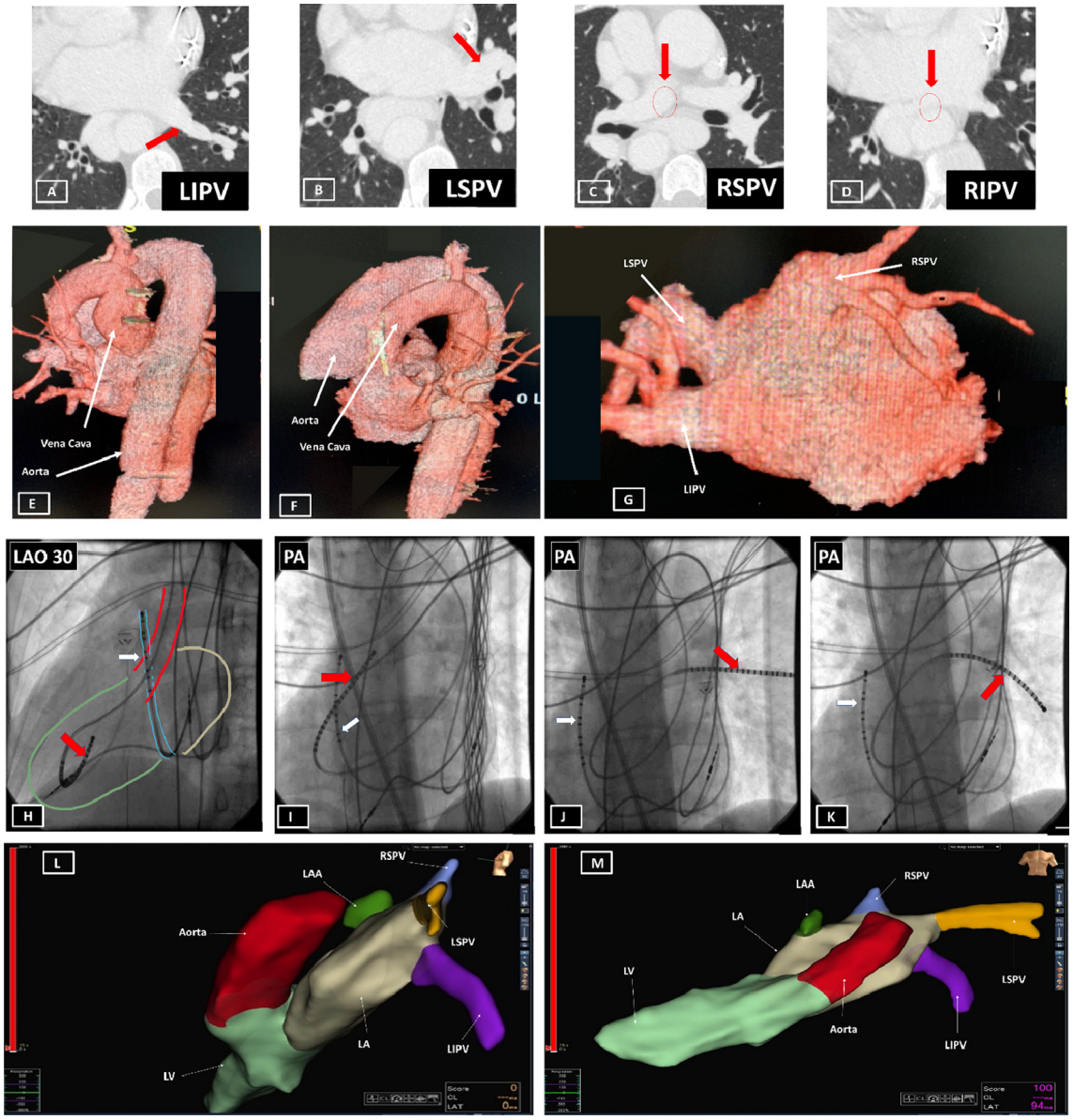

Fig. 1. Computed tomography image of the (A) left inferior pulmonary vein, (B) left superior pulmonary vein, (C) very small and posterior right inferior pulmonary vein, (D) big right superior pulmonary vein with cranially entrance in the left atrium. 3D reconstruction of the aorta, inferior vena cava (E, F), left atrium and pulmonary veins anatomy (G) obtained from the pre-interventional CT-Imaging. (H–K) Fluoroscopic anteroposterior images showed mapping catheter in the left ventricle (H), right superior pulmonary vein (I), left superior pulmonary vein (J) and left inferior pulmonary vein (K). (L) and (M) present the 3D reconstruction of the aortic root, the left ventricle, the left atrium and the pulmonary veins.

The arterial access was gained through the right femoral artery using an 8.5F SL 1 sheath to manually introduce the catheters: initially a mapping catheter which was later exchanged with an ablation catheter. In the course of the last decade the quality of mapping catheters has remarkably improved. However, the use in such a complex anatomy requires critical preliminary choices. [5] In this regard, choosing the most optimal mapping catheter for this case, we took different options into consideration:

1. A circular mapping catheter was ruled out initially due to the risk of papillary muscle entrapment when passing through the Left Ventricle (LV).
2. The high-density catheters, for example, Abbott HD Grid and Boston Scientific Orion, were also not considered optimal due to their stiffness and small distal curve.
3. After further careful deliberation, we esteemed the smooth Abbott Lifewire 20 polar catheter (with narrow spacing 2–2–2; usually used for VT mapping) the best choice.

After passing the aortic valve, the LV and the mitral valve with this catheter, mapping of the geometry and the signals of the left atrium and the PV became feasible (Fig. 1H–M).

For the planed wide antral circumferential ablation (WACA) we decided to start with the FlexAbility D/F (Abbott), hoping that the two different curves of the bidirectional catheter would help us reach all required areas. However, with this catheter it was only possible to very accurately isolate the left inferior PV (LIPV) (Fig. 2A). Respecting the stiffness of the catheter, we consciously refrained from forcefully advancing it to the superior veins. Consequently, we decided to implement a second ablation catheter,

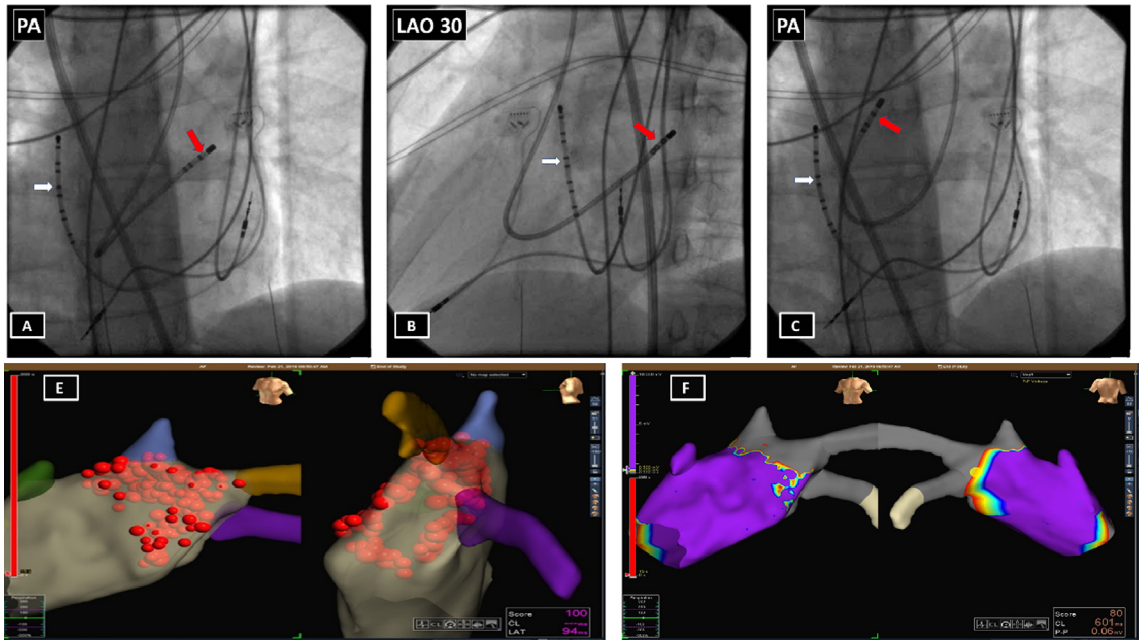

Fig. 2. (A–C) Fluoroscopic anteroposterior images showed ablation catheter in the (A) left inferior pulmonary vein using FlexAbility catheter with D/F dual curves and (B) left superior and (C) right pulmonary veins using Thermocool J-Curve ablation catheter. Red dots (E) indicate the ablation points during WACA. Successful isolation of the pulmonary veins from left atrium was confirmed after remap with the 20-polar lifewire catheter (F). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

which is smoother and offers a bigger curve (Biosense Webster, Thermocool J-Curve). With this catheter, the PVI could be successfully completed (Fig. 2B, C).

Finally, complete antral isolation was confirmed by a voltage remap so that all catheters could be withdrawn (Fig. 2D, E). Total procedure and ablation time were about 180 and 90 min respectively.

5. Conclusion

To the best of our knowledge, this is the first case report of *trans*-aortic pulmonary vein isolation in a patient with dextrocardia, situs inversus and total venous anomaly without magnetic navigation. It clearly states that with a team of experienced operators and with proper procedural planning and a broad catheter portfolio, the retrograde *trans*-aortic mapping of the LA and the PVs and WACA are feasible.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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