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Andreas Metzner, K.R. Julian Chun, D. Kivelitz and Karl-Heinz Kuck

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Successful Transseptal Puncture and Cryoballoon Pulmonary Vein Isolation in Adverse Anatomy
Interrupted Inferior Caval Vein and Azygos Continuation
Andreas Metzner, MD; K.R. Julian Chun, MD; D. Kivelitz, MD; Karl-Heinz Kuck, MD

A 56-year-old male patient was admitted for catheter ablation of highly symptomatic paroxysmal atrial fibrillation. During the procedure, a rare anatomic variation with an interrupted inferior caval vein (ICV) branching suprarenal into an azygos venous continuation draining into the superior caval vein was detected. Using angiography, a continuation of the ICV leading into the liver, subdividing into 5 smaller branches draining into the right atrium (RA), was displayed. Despite this challenging anatomic variation, successful pulmonary vein isolation (PVI) was performed.

Case Report
A 56-year-old male patient was admitted for catheter ablation of highly symptomatic drug-refractory paroxysmal atrial fibrillation (2 to 3 episodes per week), first diagnosed 48 months before the procedure. Physical examination revealed no anomalous findings, and medical history was unremarkable except for a known 1-vessel coronary artery disease with status post bare metal stent implantation in the left anterior descending artery, normal left ventricular function, and left atrial (LA) diameter of 51 mm. No LA thrombus was detected before the procedure by transesophageal echocardiography. No additional preinterventional imaging was performed.

Ablation Procedure
After written informed consent was obtained, the procedure was performed under conscious sedation using bolus of midazolam, fentanyl, and a continuous infusion of propofol (1%). Venous accesses (8F) were achieved via the right femoral vein, the left femoral vein, and the left subclavian vein. Positioning of both deflectable diagnostic catheters (7F, Webster, Biosense Webster, Diamond Bar, Calif) in the coronary sinus from the left subclavian vein and at the His-bundle region via the left femoral vein was unremarkable.

Transseptal Puncture
The guide wire for the first transseptal sheath was introduced via the right femoral vein. The guide wire exhibited an uncommon course and did not enter the RA from inferior; angiography revealed a persistent vena azygos draining into the superior caval vein (Figure 1). An additional angiography from the ICV demonstrated suprarenal branching into an azygos vein and, as another exceptional anatomic variant, a continuation of the ICV leading to the liver vein, which subdivided into 5 branches directly entering the RA (Figure 1).

Intending to minimize the periprocedural risk with regard to the challenging transseptal puncture (TP) in this unique anatomic setting, we decided to perform cryoballoon-based PVI using only a single TP. Moreover, the steerable sheath (12F, FlexCath, CryoCath, Montreal, Canada), which is used in combination with the cryoballoon system, allows complex movements within the LA and ascertains access to all PVs. The guide wire was advanced via the ICV continuation to the most medial liver vein branch (Figure 1) into the RA, providing best access to the fossa ovalis. The steerable sheath was advanced and TP was performed with pressure monitoring in standard right anterior oblique (RAO) 30° and left anterior oblique (LAO) 40° angulations. No additional imaging such as intracardiac echocardiography was used. After successful LA access, a target activated clotting time of 250 to 300 seconds was obtained.

PVI
Selective PV angiographies were performed (Figure 2) and ostial PV Lasso recordings (Lasso, Biosense Webster) were obtained (Figure 3). Selective PV occlusion angiographies with the 28-mm cryoballoon (Figure 2) were used to evaluate balloon to LA-PV junction contact because complete PV occlusion is a valuable marker of subsequent PVI success. One cryothermal energy delivery lasted 300 seconds. To early identify possible phrenic nerve injury while ablating the septal PVs, the phrenic nerve was constantly paced (10 V; 2.9 ms; cycle length, 1200 ms) via the diagnostic coronary sinus catheter, which was pulled back to the superior vena cava. After 1 ablation with perfect PV occlusion, the cryoballoon was exchanged for the Lasso catheter to check for PVI success. The right superior PV, the right inferior PV, and the left inferior PV were all isolated after 1 freeze; electric
Figure 1. A, MRI reconstruction of the congenital venous anomaly showing the suprarenal branching of the ICV into an azygos vein (AV) confluencing into the superior caval vein and in a venous continuation (VC) leading to the liver with connection to the liver vein, which separates into 5 liver vein branches (LVBs) directly entering the RA. B, Angiography of the venous continuation in 40° LAO showing 5 LVBs directly entering the RA. A diagnostic catheter (His) was advanced over 1 of the LVB and positioned at the His-bundle region. C, Scheme of the congenital venous anomaly showing the suprarenal branching of the ICV in an AV, draining into the superior caval vein and a VC leading to the liver with connection to the liver vein, which separates into 5 LVBs, directly entering the RA. A diagnostic catheter (His) was advanced over 1 of the LVB and positioned at the His-bundle region. AO indicates aorta.

Figure 2. Fluoroscopic views in 30° RAO and 40° LAO, including 1 diagnostic catheter placed in the coronary sinus (CS), 1 diagnostic catheter positioned at the His-bundle region (His), and the 12F steerable transseptal sheath (TS). A, Selective angiography of the left superior PV (LSPV) in 40° LAO. B, Lasso catheter was placed in the LSPV before and after freezing cycles to assess PV conduction in 40° LAO. C, The cryoballoon (Balloon) was placed in the LSPV in 30° RAO. A TP was placed in the esophagus. D, Selective PV occlusion angiography of the LSPV with the 28-mm cryoballoon (Balloon) to evaluate balloon to left atrium–pulmonary vein junction contact in 40° LAO. At complete occlusion, the contrast medium remains within the LSPV. A TP was placed in the esophagus.
isolation of the left superior PV required 1 additional freeze. To improve cryothermal lesions, 1 additional freeze was applied for all PVs. Finally, all PVs were successfully isolated using exclusively the 28-mm cryoballoon (Figure 3). Total procedure and fluoroscopy time accounted for 235 minutes and 81 minutes, respectively.

Postablation Treatment
The next day, pericardial effusion and pneumothorax were ruled out by chest radiography and transthoracic echocardiography, respectively. The patient was treated with intravenous heparin, and oral anticoagulation was started. The patient received coumadin targeting an INR value of 2.0 to 3.0 for at least 3 months and was kept under previous antiarrhythmic treatment for 4 weeks after ablation. After a short-term follow-up of 60 days, the patient was in stable sinus rhythm without atrial fibrillation recurrence. After the procedure, the patient was seen in the outpatient clinic and a contrast medium MRI was performed (Figure 1).

Discussion
Anomalies of the venous system may complicate catheter ablation strategies in different types of arrhythmias. Abnormalities with regard to the azygos system are rare; the prevalence was reported as up to 0.1%.1–3 Successful slow pathway ablation in atrioventricular nodal reentry tachycardia4,5 and ablation of right ectopic atrial tachycardia,6 of atrial flutter,7 and of right-sided accessory pathway8 in patients with an azygos venous continuation were reported. Successful PVI via a superior approach in patients with interruption of the ICV has been described.9 However, this is the first report of a successful left-sided ablation in an anomalous ICV with azygos continuation using an inferior access.

PVI has been established as the procedural end point for atrial fibrillation ablation,10 and cryoballoon ablation represents a novel technique for simplified PVI.11,12 In this patient, double TP, as routinely performed in an atrial fibrillation ablation case, was not feasible because of the challenging anatomic setting and the fact that only the most medial liver

Figure 3. Electrograms showing 2 surface ECG leads (I, II), 10 Lasso electrograms from the PVs, and 2 electrograms from the coronary sinus (CS), including the atrial potential (A), the ventricular potential (V), and the PV spike (asterisk). A, Baseline Lasso electrograms from right superior PV (RSPV), right inferior PV (RIPV), left superior PV (LSPV), and left inferior PV (LIPV) containing the atrial (A), the ventricular (V), and PV spike potentials (asterisk). B, The same electrograms after first freezing cycle of RSPV, RIPV, and LIPV and after second freezing cycle of LSPV. The PV spike potentials disappeared (arrow).
vein branch provided good access to the fossa ovalis. One theoretical option would have been to perform the TPs from a superior venous access. However, besides the aforementioned report, no experience exists with that approach. Therefore, we decided to perform 1 TP from inferior via the liver vein and 1 of its subdividing branches entering the RA. The cryoballoon ablation approach offers the advantage of using a steerable sheath that allows maneuvering the ablation catheter within the LA, even in this challenging anatomy. In addition, the steerable sheath can offset a potentially suboptimal location of the TP site in difficult anatomic settings. We usually also perform 2 TPs for a conventional cryoballoon PVI to assess the end point of PVI after each freeze, but in this case we intentionally accepted the option to use cryoballoon PV occlusion as a predictor of subsequent PVI. Therefore, in a first step, perfect cryoballoon PV occlusion and ablation was performed; the cryoballoon was then exchanged for the Lasso catheter and PV conduction was assessed. Using radiofrequency current energy even in conjunction with a steerable sheath would have required a second transseptal access for the Lasso catheter to evaluate PV conduction online and to obtain the end point of PVI. Cryoballoon ablation was feasible but also the only option to safely achieve the end point of PVI for our patient.

Disclosures
Dr Kuck is a consultant to CryoCath and has received research grants and honoraria for CryoCath educational lectures. Dr Chun received honoraria for CryoCath educational lectures.

References