CLINCIAL PROBLEM SOLVING

Troubleshooting the challenges of transfemoral catheter ablation of atrioventricular nodal reentrant tachycardia in a patient with congenital interrupted inferior vena cava with azygos continuation

Hafez Golzarian, DO,* Mohammad U. Shaikh, MD,* Fayaz A. Hakim, MD, FHRS†

*From the *Internal Medicine Residency Program, Mercy Health St. Rita's Medical Center, Lima, Ohio, and †Heart Rhythm Services, Division of Cardiovascular Diseases, St. Rita's Medical Center, Lima, Ohio.*

Introduction

The inferior vena cava (IVC) is the railroad for percutaneous transfemoral electrophysiology studies and catheter ablations of arrhythmias originating from both right and left sides of the heart. The vast majority of congenital anomalies of the IVC are asymptomatic and diagnosed incidentally during electrophysiologic procedures. Such IVC anomalies may preclude potentially curative catheter ablations or lead to less favorable approaches to manage cardiac arrhythmias in such situations. We present the challenging case of a conventional ablation via femoral access in a patient with an interrupted IVC with azygos continuation. We describe our methodology in successfully troubleshooting and circumventing this challenge.

KEY TEACHING POINTS

- Transfemoral radiofrequency ablations in patients with a congenitally interrupted inferior vena cava with azygos continuation manifest with a longer anatomical course, increased tortuosity, and sharp angulations at entry points to the azygos vein, superior vena cava, and right atrium.
- Despite these challenges, ablations in such instances are potentially safe, are feasible, and may be attempted prior to aborting or attempting alternative approaches.
- A superior approach via the superior vena cava and basilic vein may be preferred in such cases.
- Longer sheaths may improve catheter navigation and stability in instances using the transfemoral approach.

Case report

A 48-year-old male patient with a 1-year history of intermittent palpitations associated with dizziness refractory to metoprolol and flecainide was diagnosed with narrow complex tachycardia during one of his recent visits to the emergency room. The tachycardia terminated with 12 mg intravenous adenosine. He was referred for electrophysiology study and arrhythmia ablation. During an attempt to create a fast anatomical map of the right atrium using a 3.5-mm-tip irrigated contact force sensing ablation catheter, ThermoCool SmartTouch SF (Biosense Webster, Diamond Bar, CA), for planned fluoroless procedure, our attempts to advance or deflect the catheter at the expected right atrial level were met with resistance and no intracardiac signals were appreciated from the catheter bipoles. Attempts to navigate the catheter under fluoroscopic guidance were continuously met with resistance. Contrast venography of the IVC revealed contrast clearing directly into the superior vena cava (SVC) owing to azygos continuation of the IVC (Figure 1). The diagnostic catheters were carefully advanced under fluoroscopic guidance and positioned at the basal right ventricle instead of at the right ventricular apex owing to inadequate catheter length and at the anteroseptal tricuspid annulus close to the His location owing to catheter instability at the His location.

Because of unsuccessful attempts to place the diagnostic catheter in the coronary sinus via the femoral route, a dual-site 7F Counard curve catheter (TZ Medical, Tualatin, OR) was advanced via the right internal jugular vein and positioned into the coronary sinus with a proximal set of bipoles positioned at the right atrium (Figure 2). An ablation catheter was then used for mapping of the IVC, azygos vein, right atrium, and basal right ventricle (Figure 3). A baseline electrophysiology study showed no evidence of dual

KEYWORDS Atrioventricular nodal reentrant tachycardia; Inferior vena cava; Azygos continuation; Catheter ablation; Congenital anomalies; Transfemoral

(Heart Rhythm Case Reports 2024;10:234–237)

Address reprint requests and correspondence: Dr Fayaz Hakim, Director Arrhythmia Center, St. Rita's Mercy Medical Center, 730 West Market St, 2K Tower, Lima, OH 45801. E-mail address: fhakim@mercy.com.

https://doi.org/10.1016/j.hrcr.2024.01.001

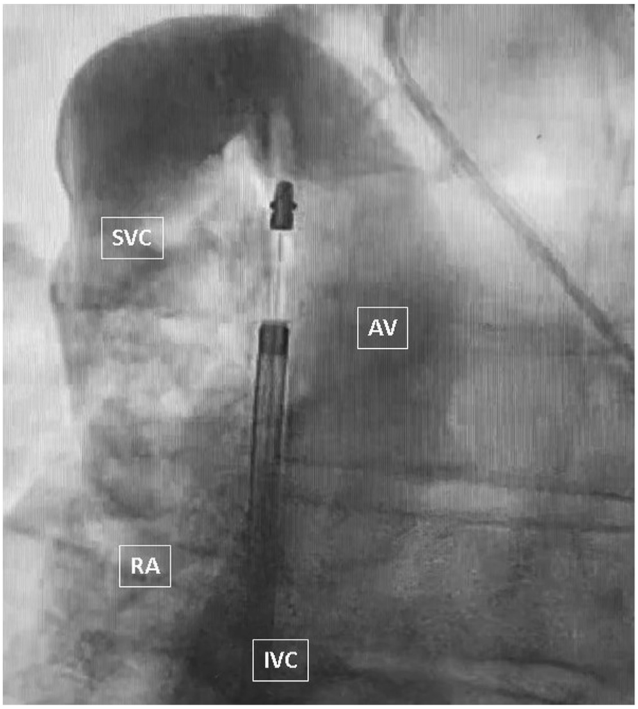

Figure 1 Shallow left anterior oblique view showing course of terminal part of inferior vena cava (IVC) continuing as azygos vein (AV) draining into superior vena cava (SVC). RA = right atrium.

atrioventricular (AV) node physiology (assessed as AV jump owing to unstable His catheter) or ventricular pre-excitation and VA conduction was concentric (anteroseptal) and decremental. Owing to unstable His catheter position and inability to advance the right ventricular catheter to the apex, para-Hisian pacing and differential ventricular pacing could not be performed. Narrow complex tachycardia was easily induced during burst atrial pacing from the proximal coronary sinus electrode pair at a pacing cycle length of 310 ms (Supplemental Figure 1). The tachycardia cycle length was 370 ms, 1:1 AV conduction, and retrograde atrial activation during tachycardia was concentric. The septal ventriculoatrial (VA) interval, measured at the proximal coronary sinus owing to unstable catheter position at the anteroseptal location, was 28 ms. Overdrive pacing from the basal right ventricle at a cycle length 20 ms shorter than the tachycardia cycle length entrained the tachycardia with VAV response (Supplemental Figure 2). The postpacing interval minus tachycardia cycle length time was 231 ms and the sinoatrial minus VA time was 200 ms. The intervals could not be corrected for AV delay during ventricular overdrive pacing owing to inconsistent His electrography. A late premature ventricular depolarization delivered from the right ventricular base did not affect the retrograde atrial activation timing (Supplemental Figure 3). His refractoriness on the premature ventricular depolarization could not be confirmed owing to inconsistent His electrography. Based on the available information derived from the tachycardia features and pacing maneuvers, a diagnosis of typical (slow-fast) AV nodal reentrant tachycardia (AVNRT) was made.

The ablation catheter was advanced into the right atrium and positioned between the coronary sinus ostium and tricuspid valve, corresponding to a right inferior extension of the slow pathway. After confirmation of a favorable ventricle/atrial electrogram ratio (during tachycardia) on distal ablation electrode bipoles of the ablation catheter, radiofrequency energy of 15 watts was delivered, which resulted in termination of the tachyarrhythmia with a single

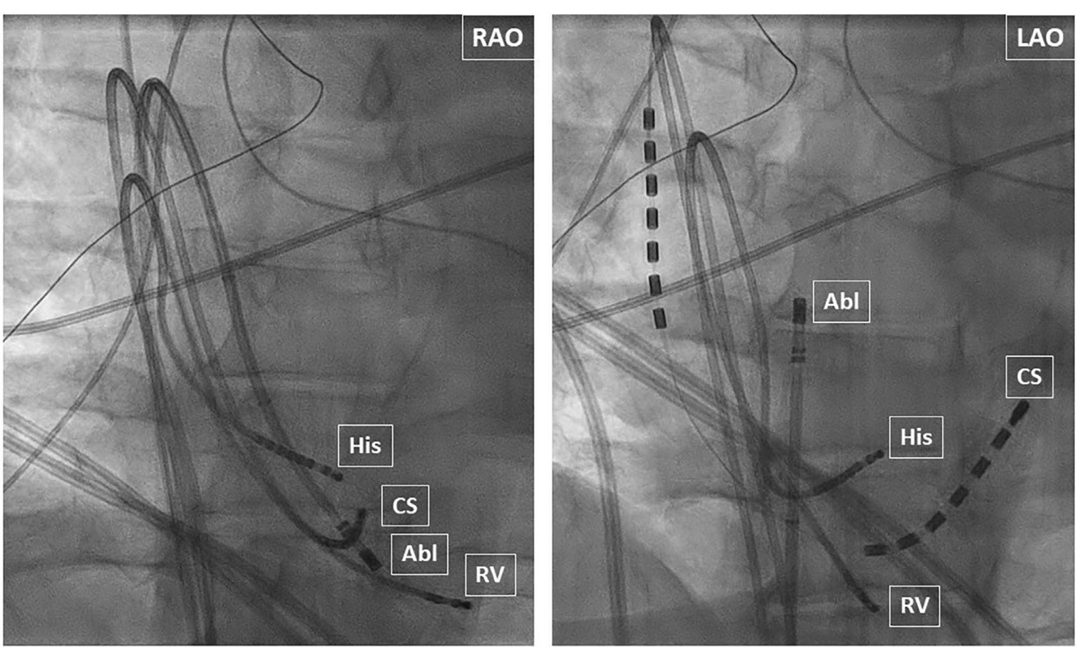

Figure 2 Fluoroscopic views showing course and positions of catheters. Abl = ablation; CS = coronary sinus catheter; His = His catheter; LAO = left anterior oblique; RAO = right anterior oblique; RV = right ventricle catheter.

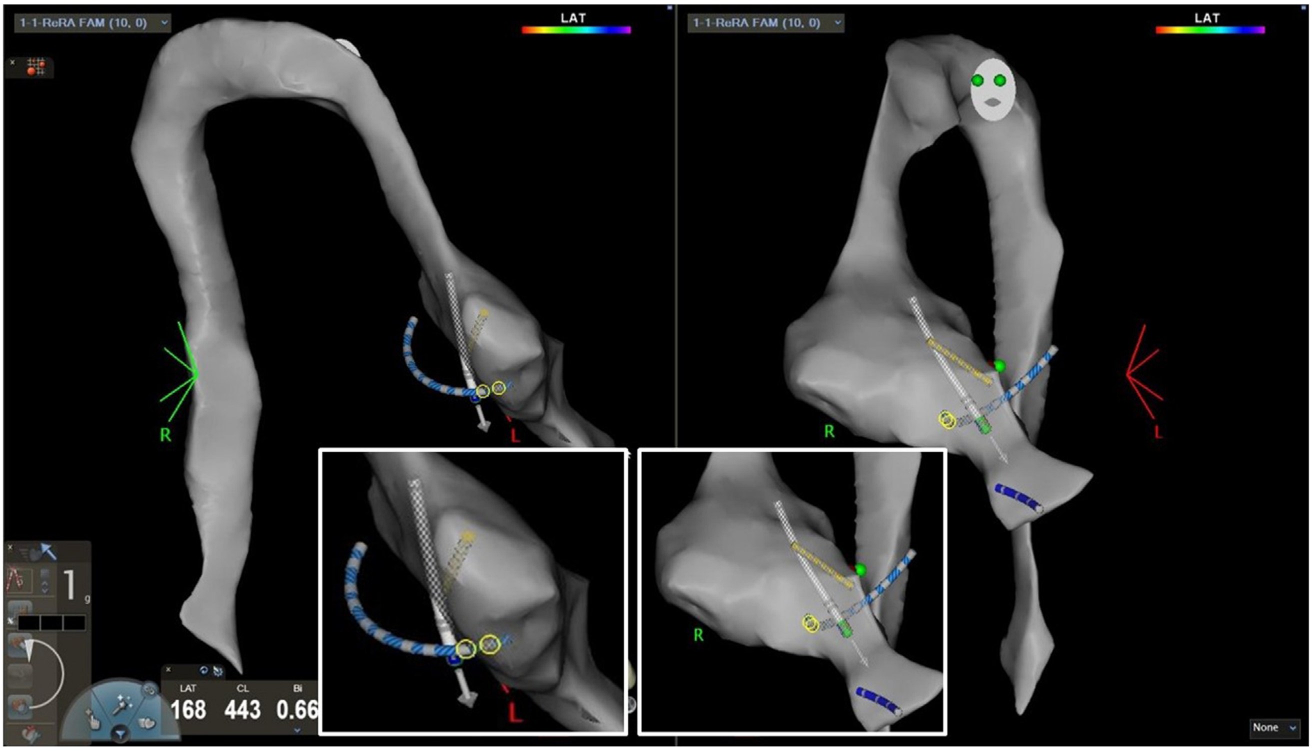

Figure 3 Fast anatomical map of inferior vena cava, azygos continuation, superior vena cava, right atrium, and basal right ventricle with catheters in place. Inserts showing zoomed views of the catheter positions. LAO = left anterior oblique; RAO = right anterior oblique.

junctional complex followed by restoration of sinus rhythm within 10 seconds (Supplemental Figure 4). The power was escalated to 40 watts and ablation continued for 60 seconds while AV and VA conduction and impedance were carefully watched. The tachycardia remained noninducible with repeat programmed stimulation and burst atrial pacing after high-dose isoprenaline (max 20 mcg/min). Postablation AV Wenckebach cycle length was 290 ms. We did not appreciate AV jump (AH could not be assessed owing to inconsistent His electrogram) during atrial extrasystole. Insurance lesions were delivered. The patient remained symptom free off antiarrhythmic drugs at 12 months follow-up. Echocardiogram showed no associated cardiac anomalies. Computed tomography scans of the abdomen and chest were recommended but the patient declined.

Discussion

We report a case of successful AVNRT ablation in a patient with interruption of the IVC with azygos continuation using a femoral approach. Azygos continuation of the IVC is a rare congenital anomaly with a prevalence of about 0.6%–1.3%.[1,2] The condition occurs in the setting of interruption of the infrahepatic segment of the IVC because of the embryological failure to form the right vitelline-subcardinal anastomosis, with regression of the right subcardinal vein. This results in shunting of the blood directly into the right supracardinal veins. Hence, blood draining into the IVC is shunted into the azygos vein, which connects the IVC with the SVC and provides an alternative path to the right atrium when either of the venae cavae is congenitally absent or atretic or interrupted owing to an acquired condition.[3] As such, the azygos vein and SVC become dilated owing to the increased flow and may be mistaken for a mediastinal mass. In typical anatomical variants, the IVC enters the right atrium at close proximity to the diaphragm and allows for facile access and advancements of catheters into the right atrium during electrophysiology studies and catheter ablations. The azygos continuation of the IVC may prevent or at least pose challenges to accessing the right atrium using a femoral approach because of its longer course, tortuosity, and sharp angulation, especially at entry points of IVC to azygos vein and azygos vein to SVC.

Restricted catheter lengths, catheter manipulation, and stability may pose additional challenges to the operator. The literature on successfully performing catheter ablation in patients with azygos continuation of the IVC using the femoral approach is very limited, with only a few case reports. These reports included ablations of AVNRT, posteroseptal/anteroseptal accessory pathways, and typical atrial flutter.[4–9] It is important for proceduralists to be aware that in such instances, less-than-favorable alternatives including superior (SVC and brachial) and transhepatic approaches should also be anticipated.[10,11] Superior approaches via the SVC and basilic veins have successfully been used in such instances and are preferred by many experienced operators. However, in the setting of a transfemoral approach, the utilization of longer sheaths allows for better navigation and maneuverability of the catheters.[4] Utilization of a preshaped Counard curve catheter introduced through the right internal jugular vein may facilitate placement of the catheter in the coronary sinus, as demonstrated in our case.

Electrophysiologists should recognize that ablations via transfemoral approaches in patients with such IVC anomalies, particularly ones with interrupted IVC with azygos continuations, are potentially safe, feasible, and that with proper equipment, may be attempted prior to aborting or attempting alternative approaches. One should not hesitate to revert to the utilization of fluoroscopy, as it remains essential to successful catheter ablations in such patients. Robotic catheter manipulation may allow better navigation of catheters and improve catheter-tissue contact.

Conclusion

Azygos continuation of the IVC is a rare congenital anomaly that may be incidentally diagnosed for the first time during electrophysiology studies and/or catheter ablation of cardiac arrhythmias. Electrophysiologists should be aware of this condition and potential challenges associated with it during catheter ablation. Although catheter ablation using a superior approach via the SVC and basilic vein can be successfully performed in such situations and is actually preferred by many experienced operators, careful catheter manipulation using combined fluoroscopy and electroanatomic mapping may also allow safe and successful ablation in the transfemoral setting. Such route may be considered if one is not comfortable with a superior approach owing to lack of familiarity or technical challenges. Robotic catheter navigation should be considered if available. Subsequent screening for other cardiac and noncardiac anomalies should of course also be considered in such patients.

Funding Sources: No funding was involved in the production of this clinical case report.

Disclosures: The authors have no financial, personal relationships, or conflicts of interest to disclose.

Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2024.01.001.

References

1. Bass JE, Redwine MD, Kramer LA, et al. Spectrum of congenital anomalies of the inferior vena cava: cross-sectional imaging findings. Radiographics 2000;20:639–652.
2. Mazzucco A, Bortolotti U, Stellin G, et al. Anomalies of the systemic venous return: a review. J Card Surg 1990;5:122–133.
3. Awais M, Rehman A, Baloch NU, et al. Multiplanar imaging of inferior vena cava variants. Abdominal Imaging 2014;40:159–166.
4. Dragasis S, Mililis P, Megarisiotou A, et al. Electrophysiologic study and catheter ablation of a supraventricular tachycardia in a patient with inferior vena cava congenital anomaly. Am J Cardiovasc Dis 2020;10:405–408.
5. Galand V, Pavin D, Behar N, et al. Atrioventricular nodal reentrant tachycardia ablation and inferior vena cava agenesis. Rev Port Cardiol 2016;35:541.e1–541.e4. English, Portuguese.
6. Arias MA, Castellanos E, Pucho Al, et al. Atrioventricular nodal tachycardia in a patient with anomalous inferior vena cava with azygos continuation and persistent left superior vena cava. Pacing Clin Electrophysiol 2009;32:1357–1358.
7. Liu QM, Zhou SH, Ouyang FF. Successful radiofrequency ablation of a right posteroseptal accessory pathway through an anomalous inferior vena cava and azygos continuation in a patient with incomplete situs inversus. Cardiol J 2009;16:164–167.
8. Amasyali B, Sen T, Kilic A. Cryoablation of an anteroseptal accessory pathway through the jugular and subclavian veins in a patient with interruption of the inferior vena cava and azygos continuation. Anadolu Kardiyol Derg 2014;14:550–553.
9. Silva AP, Merino LL, Peinado R, et al. Atrial flutter ablation through the azygous continuation in a patient with inferior vena cava interruption. Europace 2010;13:442–443.
10. Al-Sinan A, Chan KH, Young GD, et al. Systematic review of electrophysiology procedures in patients with obstruction of the inferior vena cava. J Cardiovasc Electrophysiol 2022;33:1300–1311.
11. Singh SM, Neuzil P, Skok J, et al. Percutaneous transhepatic venous access for catheter ablation procedures in patients with interruption of the inferior vena cava. Circ Arrhythm Electrophysiol 2011;4:235–241.