INNOVATIVE TECHNIQUES

COMPLEX CASE STUDY

Atrial Flutter and Anomalous Venous Anatomy

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ABSTRACT. Anomalous anatomy of the inferior vena cava is a rare occurrence, but when present can complicate electrophysiology procedures. We report a case of anomalous vena cava anatomy encountered during an attempted electrophysiology study and ablation. In this patient a left-sided inferior vena cava and azygous vein extension both drained directly into the superior vena cava, whereas the hepatic vein emptied directly into the right atrium. In our discussion we describe the importance of recognizing and mapping the anatomy, technical considerations involved in accessing the atria, and the increased risk of thrombus in these patients.

KEYWORDS. ablation, atrial flutter, azygous vein extension, inferior vena cava anomaly, thrombus.

Introduction

Anomalous anatomy of the inferior vena cava (IVC) is occasionally encountered during interventional vascular procedures. Though rare, it is important for the electrophysiologist to anticipate these abnormalities and be cognizant of the potential complications. We report a case of anomalous IVC anatomy encountered during an atrial flutter ablation.

Case report

The patient is a 60-year-old man with a history of coronary disease complicated by myocardial infarction and a reduced left ventricular ejection fraction, who had a dual-chamber implantable cardioverter-defibrillator placed for primary prevention of sudden cardiac death. He presented to our institution’s emergency department complaining of epigastric pain. Evaluation included an electrocardiogram that demonstrated typical atrial flutter, which subsequently converted spontaneously to sinus rhythm. Because of symptomatic atrial flutter, he was referred for an electrophysiology study and ablation.

At the time of the procedure, bilateral femoral venous access was obtained uneventfully via the Seldinger technique. Catheters advanced through the left and through the right-sided access sites reached the level of the right atrium (RA); however, the catheters appeared to take an unusual course fluoroscopically as they entered the RA and crossed the tricuspid valve. Anomalous vascular anatomy was suspected.

Contrast venography revealed evidence of a persistent left-sided IVC (LIVC). On the right, there was evidence of a connection to the LIVC and an innominate vein, likely an azygous vein (AZV) extension (Figure 1a,b). A pigtail catheter was advanced from the left-sided venous access to the RA via the LIVC. Via the right femoral access site, a decapolar catheter was advanced through the AZV extension (Figure 2). The decapolar catheter was then advanced into the RA and atrial signals were recorded, confirming RA placement (Figure 3 inset).

Further venography demonstrated that neither the LIVC nor the AZV extension connected directly to the RA, but instead emptied into the superior vena cava (SVC), which subsequently reached the RA (Figure 3). When the pigtail catheter was advanced in the RA it became evident that there was another vein connecting to the lower aspect of the RA. The pigtail catheter was exchanged for a multipurpose catheter and venography
was repeated revealing a direct hepatic vein (HeV) to RA connection (Figure 4).
 Thus, the HeV drained directly into the lower RA, the LIVC drained into the AZV, and the confluence of these two vessels along with an AZV extension drained into the SVC before entering the RA (Figure 5). Because of the anomalous venous anatomy, catheter ablation was deferred.

Discussion

Incidence

Congenital venous anomalies of the central vessels may occur in 0.2–3% of patients. Eight variations in IVC anatomy have been described including a single left-sided vena cava, double or duplicate vena cava, and vena cava with azygous extension. This variability is not surprising given the complex embryogenesis that involves the creation, regression, and anastomoses of three pairs of primitive vessels. Though somewhat rare, it is important to for the interventional electrophysiologist to anticipate these abnormalities, and be cognizant of the potential complications.

Recognition

Ordinarily cannulation of the IVC is suggested by catheter appearance to the right of the spine when

Figure 1: Right and left femoral venography revealing a persistent left-sided inferior vena cava (LIVC) and an innominate vessel, likely an azygous vein (AZV) extension. There is no evidence of a right-sided IVC.

Figure 2: Cannulation of the persistent left-sided inferior vena cava (LIVC) with a 6-French angled pigtail catheter via the left common femoral vein. Cannulation of the azygous vein extension (AZV) with a 6-French decapolar electrode via the right common femoral vein.

Figure 3: The pigtail catheter (straight arrow) and electrode catheter (curved arrow) become confluent in the superior vena cava (SVC) before entering the right atrium as noted with contrast injection. Inset: Recording from electrode including lead V6; and proximal (P), mid (M), and distal (D) bipoles.
viewed in the anterior-posterior position. When catheters appear to the left of the spine an IVC anomaly should be considered after arterial cannulation is excluded. Once it is confirmed that the catheter is luminal within the venous system, venography can identify the safest means of obtaining right atrial access.

**Accessing the atria**

Various methods of achieving right atrial access have been successfully used in patients with venous anomalies including the AZV extension via a femoral puncture, superior approach via the internal jugular or subclavian vein, hepatic vein access via a percutaneous puncture, and use of bilateral vena cava. The optimal approach should be guided by the anatomy encountered as well as operator experience.

**Increased risk of thrombus**

When deciding to advance a catheter through an anomalous vein, the operator must consider the risk of thrombus development. It has been widely reported that patients with anomalous vena cava anatomy, even those that are young and without identifiable comorbidities, are at higher risk for lower extremity deep vein thrombosis and IVC thrombus. This has been attributed to abnormal stenosis, angle, or compression by extraneous structures.

It is likely that the risk of thrombus in these patients is increased by catheter advancement through tortuous vessels causing endothelial damage. Taniguchi et al reported a case of IVC thrombus leading to pulmonary embolism following an electrophysiology procedure in a patient with a duplicated IVC.

**Conclusion**

Suspicion and subsequent confirmation of a vascular anomaly in patients undergoing interventional EP procedures is a critical step in achieving RA access, as well as managing a patient’s peri-procedural risk. Assessment of vessel size and course should be evaluated when deciding the most appropriate means of accessing the atria. If the vessel is of small caliber or acutely angled, we would recommend considering a superior approach to decrease the risk of endothelial injury and subsequent thrombosis.

**References**

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