Radiofrequency Catheter Ablation of Atrioventricular Nodal Reentrant Tachycardia in Patient with Interruption of Inferior Vena Cava

We present a 72-year-old man with interruption of inferior vena cava (IVC) with azygos continuation, who underwent radiofrequency catheter ablation of atrioventricular nodal reentrant tachycardia (AVNRT).

We recorded a His bundle electrogram with an electrode catheter positioned in the aortic root. We also introduced an electrode catheter through the right femoral vein, advanced it via an enlarged azygos vein and the superior vena cava and positioned it at the right ventricular apex (RVA). AVNRT was induced by programmed pacing from a coronary sinus catheter introduced through the left subclavian vein. It was successfully ablated with an ablation catheter introduced through the right internal jugular vein.

In a patient with interruption of IVC, it is impossible to access the right side of the heart directly via femoral vein and IVC. In this case, however, alternative routes to the His bundle, RVA and ablation site enabled us to perform an electrophysiologic study and a successful catheter ablation.

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Key words: Arrhythmia, Azygos vein, Venous anomaly, Electrophysiologic study, Right cardiac catheterization

Introduction

Radiofrequency catheter ablation is a safe and reliable modality of therapy for curing various cardiac arrhythmias.\(^1\)\(^-\)\(^3\) For this purpose, several diagnostic and ablation catheters are introduced mainly through femoral veins and positioned in various intracardiac locations to record local electrograms and/or to ablate substrates of arrhythmias.

The most common venous anomaly involving the inferior vena cava (IVC) is absence of its infrahepatic segment (interruption of IVC) with azygos continuation to the superior vena cava (SVC).\(^5\)\(^)\) The dilated azygos system serves as the major channel of systemic venous return from the lower half of the body.

Although there are usually no clinical manifestations in a patient with interruption of IVC unless
the patient has other anomalies, interruption of IVC has a serious clinical significance in case a patient needs clinical assessment and/or intervention using IVC as a route of various catheters, for example, assessment by Swan-Ganz catheter, temporary ventricular pacing, electrophysiologic study (EPS) and catheter ablation.

We report on a patient with atrioventricular nodal reentrant tachycardia (AVNRT) and interruption of IVC who underwent EPS and subsequent successful radiofrequency catheter ablation of the slow pathway conduction using alternative routes of catheters.

Case Report

A 72-year-old male was taken to our emergency room due to an attack of palpitations. The 12-leads electrocardiogram (ECG) showed a narrow QRS complex tachycardia at the rate of approximately 200 beats/min. The tachycardia was converted to sinus rhythm with an intravenous injection of 5 mg of verapamil. During sinus rhythm, the ECG showed positive P waves in II, III, and aVF.

Given the symptomatic status of the patient, he was admitted to our hospital for EPS and catheter ablation.

In screening echocardiography, the atrial and ventricular structures were normal. The great arteries were normally aligned with their respective cardiac chambers. In a subcostal scan we could not recognize IVC draining into the right atrium, which we attributed to technical difficulty at that time.

In the first EPS session, the right femoral vein was cannulated and a guidewire was inserted. The guidewire crossed over to the left side of the spine. Contrast medium was injected after an introducer was inserted in the femoral vein, and it revealed that the patient had interruption of IVC with azygos continuation.

We suspended the procedure and assessed the status of the cardiovascular system of the patient with contrasted computed tomography.

There were bilateral IVCs and renal veins on each side drained to IVCs of the same side. The left IVC was dominant and connected to an enlarged hemiazygos vein. The right IVC was relatively small and connected to the right common iliac vein at the vicinity of the bifurcation formed by the left IVC and bilateral common iliac veins.

This enlarged hemiazygos vein, which was located in the dorsal position of the descending aorta, coursed behind the heart and drained to the azygos vein. The azygos vein was markedly enlarged and 25 mm in diameter at a point just before the draining portion to the SVC. Although the hepatic vein was detected to enter the right atrium, the infrahepatic segment of IVC was absent (Figure 1(a)).

There were no other significant anomalies in the venous system including a persistent left superior vena cava. There were no anomalies in relation to the spleen or other systemic organs.

In abdominal echography, it was clearly revealed that the infrahepatic segment of the IVC was absent and the hepatic veins directly entered the inferior aspect of the right atrium. The enlarged hemiazygos vein was also visualized in the dorsal position of the abdominal aorta (Figure 1(b)).

In the second EPS session, we introduced a non-deflectable 7F decapolar catheter (401132: St. Jude Medical, St. Paul, Minesota, USA) through the left subclavian vein and inserted it into the coronary sinus ostium using the CS catheter.

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We also introduced a deflectable 6F quadripolar catheter (D6DR252RT: Biosense-Webster, Diamond Bar, CA, USA) through the right femoral artery and positioned it in the aortic root to record a His bundle electrogram which was easily accomplished.

We also introduced a deflectable 6F quadripolar catheter (D6DR252RT: Biosense-Webster, Diamond Bar, CA, USA) through the right femoral vein, advanced by way of the azygos vein, SVC and right atrium and positioned it at the right ventricular apex (RVA). The catheter placement was possible due to the well-developed nature of the azygos vein, although the tortuous nature of the azygos continuation made it difficult to manipulate the catheter appropriately. The positions of the diagnostic catheters are shown in Figure 3.

The right ventricular pacing showed that the retrograde conduction was decremental. We did not perform para-Hisian pacing because of the difficulty of manipulating the right ventricular catheter. Atrial extrastimuli pacing from the CS ostium demonstrated antegrade dual atroventricular pathways.

A narrow QRS complex tachycardia was induced by programmed pacing from the CS ostium (Figure 4(a)). The tachycardia was identical in morphology to clinical tachycardia and had a cycle length of 370 ms (162 beats/min).

It was difficult to record retrograde atrial activation during tachycardia in the catheter for the His
bundle electrogram located in the aortic root. The recordable shortest VA interval during tachycardia was 52 ms at the CS ostium recording site (CS9-10). A premature ventricular stimulus given during the refractory period of the His bundle did not reset the tachycardia cycle. As a result, the patient was diagnosed with AVNRT.

Although a relatively short VA interval suggested that the retrograde conduction of this AVNRT went up the fast pathway, we could not determine whether this AVNRT was a slow-fast type AVNRT or another type, for example, slow-slow type AVNRT, because the true earliest site of atrial activation was not clearly determined.

An ablation catheter (Ablaze221-4DL: Japan Lifeline, Tokyo, Japan) was introduced through right internal jugular vein. We positioned it under fluoroscopic guidance at the inferoposterior area of Koch’s triangle where a slow pathway potential was identified (Figure 4(b)).

The position of ablation catheter is shown in Figure 3. Radiofrequency current was applied at 42 V (25 W) with temperature cut-off at 55°C. Junctional rhythm was noted and radiofrequency current delivery was continued for 60 s. After 2 applications of radiofrequency current, dual atrioventricular nodal physiology was eliminated and we could not induce any echo beats before or during isoproterenol infusion.

The procedure was terminated as we confirmed AVNRT could not be induced and slow pathway conduction was absent in EPS 30 min after ablation. The procedure and fluoroscopy times were 135 and 22 minutes, respectively. There was no complication and the patient is free from palpitation for 6 months after the catheter ablation.

Figure 1  Contrasted computed tomography (a), and abdominal echography (b) of the interruption of inferior vena cava (IVC) with azygos continuation.

(a) The azygos vein was markedly enlarged and 25 mm in diameter at the point just before portion draining into the superior vena cava (Panel A). Although the hepatic vein was found to enter the right atrium (Panel B), the infrahepatic segment of the IVC was absent (Panel C). Note that the hemiazygos vein, which was located in the dorsal position of the thoracic aorta, was also enlarged (Panel B,C). The hemiazygos vein coursed behind the heart and drained to the azygos vein.

(b) The infrahepatic segment of the IVC was absent and the hepatic veins directly entered the inferior aspect of the right atrium (Panel D). The enlarged hemiazygos vein was visualized in the dorsal position of the abdominal aorta (Panel E).

SVC: superior vena cava, AZ: azygos vein, HV: hepatic vein, AO: aorta, HA: hemiazygos vein
Discussion

Interruption of IVC is the most common anomaly of IVC and results from failure of the right subcardial vein to develop properly and to anastomose with the right vitelline vein in the developing embryo. In most cases, systemic venous return from the lower part of the body drain to SVC through a markedly enlarged azygos and/or hemiazygos vein.

The patient in this case has no clinically significant anomalies other than interruption of IVC. However,
interruption of IVC is frequently associated with complex cardiac defects, and has a strong association with left atrial isomerism and polysplenia. The reported incidence of this anomaly approximates 0.6% in patients with congenital heart defects. The technical difficulty that can accompany cardiac catheterization is the major concern of this anomaly in the surgical correction of cardiac defects.

It is estimated that the incidence of interruption of IVC among candidates of catheter procedures from the femoral vein is lower than that among the patients with congenital heart defects. Among the consecutive 1,879 patients in our hospital who underwent right cardiac catheterization for clinical assessment and/or intervention from Oct. 2001 to Oct. 2008, only 2 patients (0.11%) had interruption of IVC, one of whom was the patient in this case.

In patients with interruption of IVC without other anomalies, there are usually no clinical manifestations and no treatment is needed. But interruption of IVC can interfere with EPS and catheter ablation since the catheters are usually inserted from the femoral veins and advanced by way of the IVC before entering the right side of the heart.

In this report, we describe a case of successful radiofrequency catheter ablation of AVNRT in a patient with interruption of IVC and azygos continuation using alternative catheter approaches which differ from normal catheter settings.

Although there are some case reports of successful radiofrequency catheter ablation of atrioventricular reentrant tachycardia (AVRT) in patients with interruption of IVC and azygos continuation, we could not find any report of successful radiofrequency catheter ablation of AVNRT in a patient with interruption of IVC and azygos continuation in our review of the literature.

In our case, a diagnostic catheter for the His bundle was positioned in the aortic root using a retrograde transaortic approach, because mapping of the His bundle with the diagnostic catheter situated inside the coronary sinus, RVA: right ventricle apex, H: His bundle potential, ABL: ablation, SPp: slow pathway potential.

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**Figure 4** (a) Initiation of atrioventricular nodal reentrant tachycardia by atrial extra-stimulation.

Stimulation is carried out from coronary sinus ostium (CS9-10) at a basic pacing cycle length of 600 ms. At a coupling interval of 280 ms, atrioventricular nodal reentrant tachycardia is induced.

(b) Intracardiac electrocardiogram at the successful ablation site. Slow pathway potential is recorded at the inferoposterior area of Koch’s triangle. Radiofrequency current application at this site eliminated slow pathway conduction. ILV1: surface ECG leads IL, V1, HBE: His bundle electrogram, CS1-10: intracardiac electrogram recorded from diatal, 2nd, 3rd, 4th, and 5th pair of electrodes from decapolar catheter situated inside the coronary sinus, RVA: right ventricle apex, H: His bundle potential, ABL: ablation, SPp: slow pathway potential.
nature of the azygos vein. In case it had been difficult, however, retrograde transaortic approach to the left ventricle from the femoral artery would have been used for recording and pacing the ventricle.

Catheterization of the CS was accomplished with ease through the left subclavian vein. Atrial pacing was possible from the CS catheter and we could perform standard EPS except for para-Hisian pacing in these clinical settings.

We introduced an ablation catheter through the right internal jugular vein and positioned it at the inferoposterior area of Koch’s triangle. There was no difficulty in manipulating the ablation catheter and the slow pathway potential was easily identified. The slow pathway conduction was ablated with 2 applications of radiofrequency current.

We could not determine before EPS whether the supraventricular tachycardia of the patient was AVNRT or AVRT. If it had been a case of AVRT due to a concealed left accessory pathway, we could have mapped the accessory pathway with the CS catheter and an ablation catheter advanced by a retrograde transaortic approach into the left ventricle, which may have posed no difficulty. If this had been a case of AVRT due to a concealed right accessory pathway, however, the procedure may have been more difficult because we may have had to introduce another mapping catheter to the tricuspid valve anulus or right atrial septum to map the accessory pathway.

We could not diagnose interruption of IVC by the first screening echocardiography, although we could not recognize the IVC draining into the right atrium. We attributed it to technical difficulty at that time.

It was reported that the diagnosis of IVC interruption in children was easily made with cross-sectional echocardiography. We should always take into account the possibility of this anomaly of IVC, even if it is rare, in the assessment of echocardiography, especially before a clinical procedure using IVC as a route for catheterization.

When the detection of IVC is difficult in echocardiography in an adult case, abdominal echography may be a suitable noninvasive method for diagnosis of interruption of IVC, as suggested in this case.

References


