Catheter ablation of the atrioventricular node slow pathway sans fluoroscopy in a patient with situs inversus totalis

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Introduction

Situs inversus, also known as situs transversus or situs oppositus, is a rare congenital anomaly with an incidence of ∼0.01% in the general population.[1] It is classified as either partial or total.[1] Situs inversus totalis is the most common form of congenital visceral ectopia and it is caused by visceral malrotation during the embryonic stage.[1] In these individuals, there is complete transposition (right-to-left reversal) of the heart and the abdominal organs, whereas the relationship between the viscera is preserved.[1] Furthermore, situs inversus totalis can also be associated with unusual anatomical locations of certain cardiovascular structures, such as the superior and the inferior venae cavae as well as the sinoatrial and the atrioventricular (AV) nodes.[1] Consequently, catheter ablation of cardiac arrhythmias in patients with this type of anomaly can pose technical challenges, necessitating accurate identification of key anatomical landmarks.

Case report

A 49-year-old man presented with an adenosine-sensitive, short R-P tachycardia at a rate of 188 beats per minute (Figure 1A). He had a known history of situs inversus totalis (Figure 1B) with preserved left ventricular systolic function and Kartagener syndrome. Owing to the recurrent and profoundly symptomatic nature of the arrhythmia, the patient opted for an electrophysiology study with catheter ablation under monitored anesthesia care. At the start, 3-dimensional (3-D) fast anatomical mapping (CARTO; Biosense Webster, Inc, Irvine, CA) was performed fluorolessly using an 8.5F, 3.5-mm-tip force-sensing radiofrequency mapping/ablation catheter (ThermoCool SmartTouch; Biosense Webster, Inc). Next, diagnostic electrophysiology mapping catheters including a decapolar coronary sinus mapping catheter (Dynamic XT; BARD, Covington, GA) and a quadripolar His catheter (Josephson; Boston Scientific Corporation, Marlborough, MA) were inserted fluorolessly through venous introducers, via the femoral vein. A comprehensive electrophysiology study was subsequently performed and demonstrated normal intracardiac conduction intervals with an AH interval of 95 milliseconds, an HV

KEY TEACHING POINTS

- Situs inversus is a rare congenital anomaly with an incidence of ∼0.01% in the general population.
- Situs inversus can be associated with unusual anatomical locations of certain cardiovascular structures, such as the superior and the inferior venae cavae as well as the sinoatrial and the atrioventricular (AV) nodes.
- Catheter ablation of cardiac arrhythmias in patients with situs inversus can pose technical challenges, necessitating accurate identification of key anatomical landmarks.
- Not only can 3-dimensional electroanatomic mapping substantially enhance radiofrequency ablation of supraventricular tachycardia mechanisms such as AV node reentry tachycardia in patients with dextrocardia and situs inversus, but it allows for safe and effective performance of the procedure sans fluoroscopy.

KEYWORDS AV node; AVNRT; Catheter ablation; Situs inversus; Slow pathway; SVT
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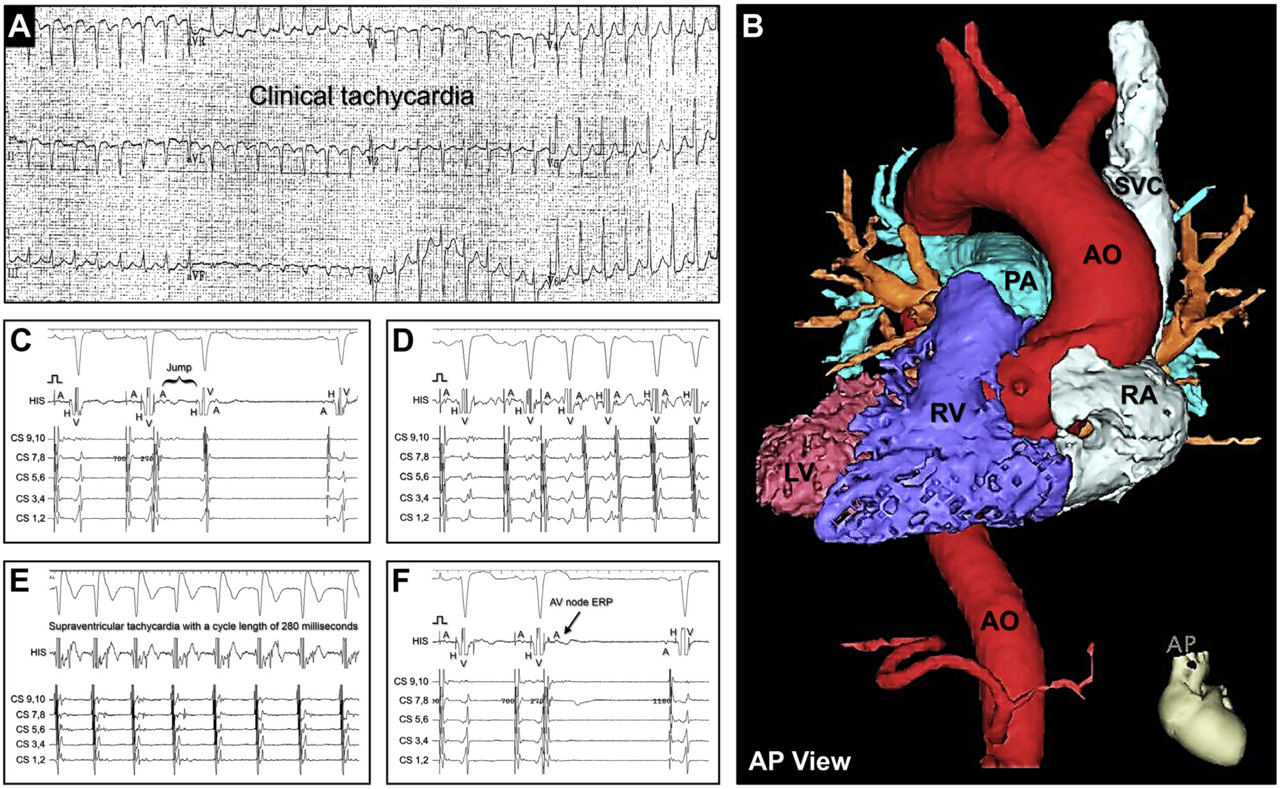

Figure 1 The electrocardiographic and intracardiac recordings and anatomic imaging. **A:** A 12-lead electrocardiogram obtained in the Emergency Department prior to administration of intravenous adenosine, demonstrating a short R-P tachycardia, at a rate of 188 beats per minute. The electrocardiogram is consistent with presence of dextrocardia, evident by negative QRS complexes and T waves in lead I, positive QRS complexes and T waves in lead aVR, and right axis deviation. **B:** An image segmented from a computed tomography scan demonstrating the patient's anatomy in an anterior-posterior projection (AP), consistent with situs inversus. The ensuing 4 panels (**C–F**) depict intracardiac electrocardiograms obtained at electrophysiology study. **C:** Intracardiac electrocardiograms illustrating dual atrioventricular (AV) node physiology, demonstrated by the presence of a "jump" when performing programmed extrastimulation from the coronary sinus at 700/270 milliseconds. **D:** The same maneuver subsequently induced a sustained supraventricular tachycardia with a mean cycle length of 280 milliseconds. **E:** The H-A time during tachycardia is short, consistent with typical slow-fast AV node reentrant tachycardia. **F:** Post–catheter ablation intracardiac electrocardiograms redemonstrating programmed extrastimulation from the coronary sinus at 700/270 milliseconds. This time, during the same maneuver, the AV node is found refractory, consistent with successful ablation and elimination of the AV node slow pathway. A = atrial electrogram; AO = aorta; AV = atrioventricular; CS = coronary sinus catheter recording from proximal (9,10) to distal (1,2); ERP = effective refractory period; H = His bundle electrogram; His = His catheter recording; LV = left ventricle; PA = pulmonary artery; RA = right atrium; RV = right ventricle; SVC = superior vena cava; V = ventricular electrogram.

interval of 42 milliseconds, and evidence of dual AV node physiology (Figure 1C). The AV node fast pathway effective refractory period (ERP) was reached when stimulating from the coronary sinus at 700/270 milliseconds and AV node slow pathway ERP at 700/210 milliseconds, with an atrial ERP of 700/200 milliseconds. Programmed extrastimulation resulted in the induction of a sustained supraventricular tachycardia with a mean cycle length of 280 milliseconds (Figure 1D). The H-A time during tachycardia was short, consistent with typical slow-fast AV node reentrant tachycardia as well as the patient's clinical tachycardia (Figure 1E). Consequently, radiofrequency ablation (RFA) of the AV node slow pathway was performed using the ablation catheter inserted via a long introducer (SR-0 sheath; Abbott, St. Paul, MN), without the use of fluoroscopy, guided exclusively by 3-D electroanatomic mapping.

Briefly, a 3-D electroanatomic map of the right atrium and the adjacent structures including the coronary sinus, the tricuspid valve, and the inferior and superior venae cavae was created using the open-irrigated, force-sensing RFA catheter. Subsequently, radiofrequency applications using 30 W delivered to the site of the AV node slow pathway triggered slow junctional beats (Figure 2). Several stable applications with sufficient contact force (∼15 g) were delivered to this site. Postablation, absence of dual AV node physiology was confirmed, consistent with successful RFA of the AV node slow pathway (Figure 1F). The procedure was completed within 87 minutes, which was comparable in duration to other similar types of ablations/procedures performed by our group within our laboratory when using fluoroscopy. Moreover, the patient had a favorable outcome and he has remained arrhythmia-free during long-term follow-up.

Discussion

Although catheter ablation of supraventricular tachycardias[2,3] and other similar arrhythmias[4] in patients with dextrocardia and situs inversus has been previously described, to our knowledge, this is the first report of such a procedure

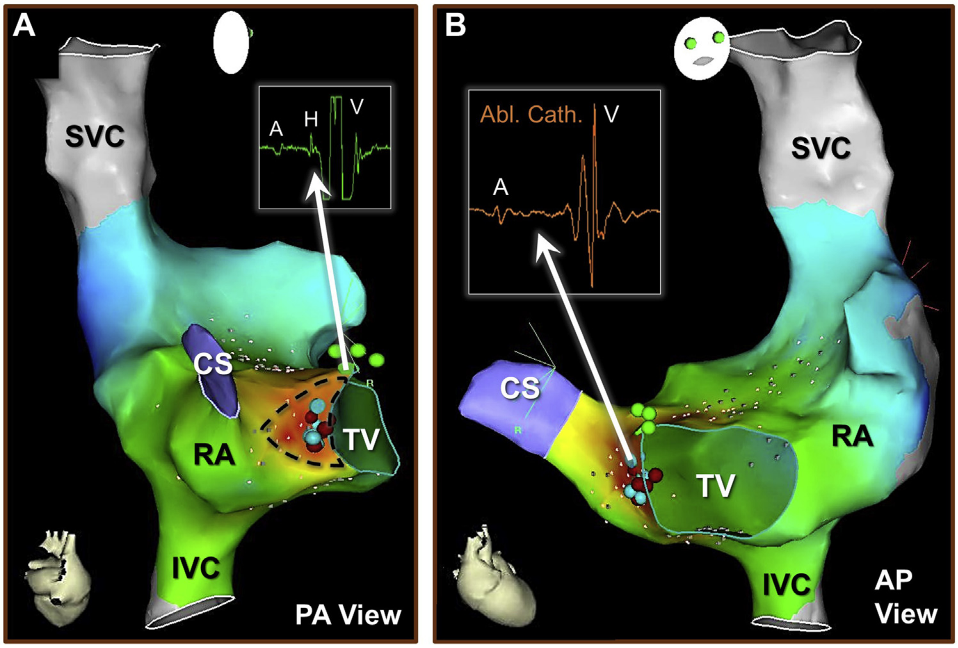

Figure 2 Three-dimensional (3-D) electroanatomic maps in posterior-anterior (PA) (**A**) and anterior-posterior (AP) (**B**) projections illustrating the site of catheter ablation (*red and blue lesions*), within the triangle of Koch (*black dotted lines*), bounded by the coronary sinus orifice, the tendon of Todaro, and the septal leaflet of the tricuspid valve. The green circles represent the location of His, as marked and recorded by the ablation catheter prior to radiofrequency ablation. The inset in panel A depicts the recoding of His at this anatomical site (denoted by the *white arrow*). The inset in panel B illustrates the intracardiac electrogram recorded using the ablation catheter (Abl. Cath.) at the site of radiofrequency ablation (denoted by the *white arrow*). The blue lesions mark the sites where slow junctional beats were observed during catheter ablation. CS = coronary sinus; IVC = inferior vena cava; RA = right atrium; SVC = superior vena cava; TV = tricuspid valve.

performed sans fluoroscopy. The strategy and the benefits of fluoroscopy-free catheter ablation have been well established.[5,6] Radiation exposure related to catheter ablation carries small but non-negligible stochastic and deterministic effects on one's health. Such detrimental effects are cumulative and potentially more harmful in younger individuals. Meanwhile, 3-D electroanatomic mapping offers the ability to significantly reduce and in some cases completely eliminate the need for radiologic exposure.[5–7] To date, there have been only a few reports on fluoroless catheter ablation in patients with congenital anomalies.[8,9] As illustrated, in the current case, 3-D electroanatomic mapping not only substantially enhanced the RFA of the arrhythmia mechanism in the described patient with dextrocardia and situs inversus totalis, but it allowed exclusively for the performance of the procedure in its entirety through the use of 3-D mapping while eliminating altogether the need for fluoroscopic utilization. Meanwhile, the authors believe that this approach can also be utilized safely and effectively for mapping and ablation of cardiac arrhythmias in other forms of congenital heart disease and similar types of complex cardiac anatomies.

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