

[CASE REPORT]

Successful Catheter Ablation for Multiple Atrial Arrhythmias in a Patient with Situs Inversus Totalis

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Abstract:

A 70-year-old woman with situs inversus totalis underwent catheter ablation for atrial fibrillation and atrial flutter. Although her morphologic left atrium (LA) was enlarged, we performed cryoballoon ablation and liner radiofrequency ablation of the cava-tricuspid isthmus without mapping atrial arrhythmias. However, a different form of atrial tachycardia (AT) recurred. We performed catheter ablation a second time using a three-dimensional electroanatomic mapping system. AT was not terminated by the liner ablation at the roof of morphologic LA and mitral isthmus but sustained by changing the atrial activation sequence and cycle length. Multipolar mapping catheter revealed that fractionated low-amplitude potentials were densely located in a limited area of the anterior morphologic LA, and an activation map demonstrated the presence of small-circuit reentry with an extremely slow conduction at the anterior morphologic LA. A single energy application targeting the fragmented potentials successfully terminated the AT. We successfully treated multiple ATs with a complex anatomy using a three-dimensional electroanatomic mapping system.

Key words: situs inversus totalis, cryoballoon ablation, multiple atrial tachycardia, small closely spaced electrodes, three-dimensional electroanatomic mapping system

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Introduction

Dextrocardia with situs inversus is a rare congenital anomaly occurring with an estimated frequency of 1 : 8,000 to 1 : 10,000 (1, 2), with the connection between the atrium and the ventricle normal in many cases (3). This situation is technically challenging to manage via percutaneous procedures.

We herein report a case of multiple atrial reentrant tachycardia with situs inversus totalis successfully treated by two-staged procedures. A three-dimensional electroanatomic mapping system using a multipolar mapping catheter with small, closely spaced electrodes was useful for treating arrhythmias with a complex anatomy.

Case Report

A 70-year-old woman was admitted to a hospital because of congestive heart failure with reduced left ventricular sys-

toxic function. Twelve-lead electrocardiography (ECG) revealed atrial flutter with a rapid ventricular rate (AT1, Fig. 1A), which spontaneously converted into atrial fibrillation (AF) and ultimately returned to sinus rhythm. Because the left ventricular function was recovered after treatment of atrial fibrillation, she was diagnosed with tachycardia-induced cardiomyopathy. She was then referred to our hospital to undergo catheter ablation.

Chest X-ray and computed tomography (CT) revealed dextrocardia with situs inversus totalis and polysplenia (Fig. 2A, B). Although her morphologic left atrium (LA) was enlarged (LA diameter 45 mm, LA volume 135 mL), we performed cryoballoon ablation and liner radiofrequency ablation of the cava-tricuspid isthmus (CTI) without mapping the atrial arrhythmias to simplify the procedure. Transseptal puncture was achieved using intracardiac ultrasound via the left femoral vein. Four pulmonary veins (PVs) were successfully isolated using the Arctic Front Cryoballoon Catheter (Medtronic, Minneapolis, USA), and CTI ablation was performed by irrigation ablation catheter (FlexAbility

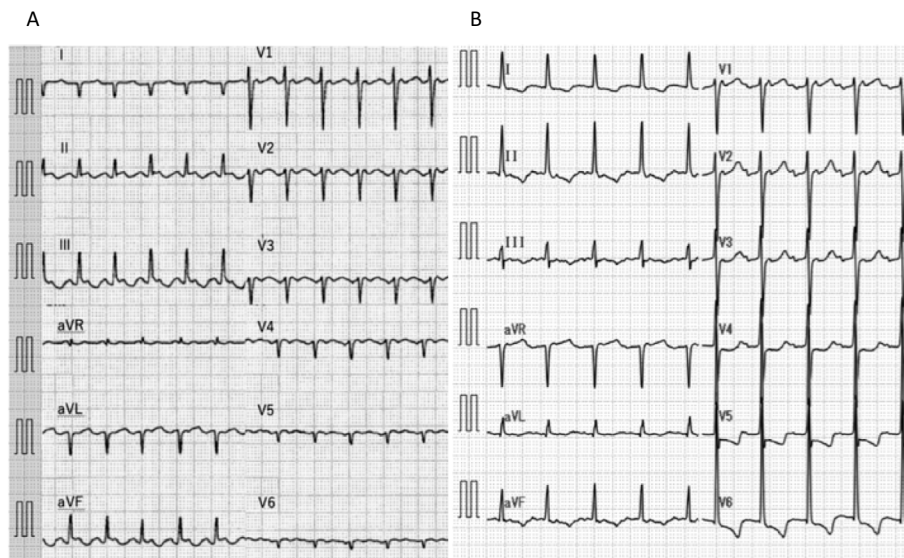


Figure 1. A: Twelve-lead ECG of atrial flutter (AT1) recorded at the first admission. ECG was recorded with normal electrode positions in the first hospital. The heart rate was 148 beats per minute, and the cycle length of the F wave was 200 ms. B: Twelve-lead ECG of recurrent atrial tachycardia (AT2) recorded with reversed right- and left-side electrodes. The cycle length of AT2 (260 ms) was different from that of AT1 (200 ms).

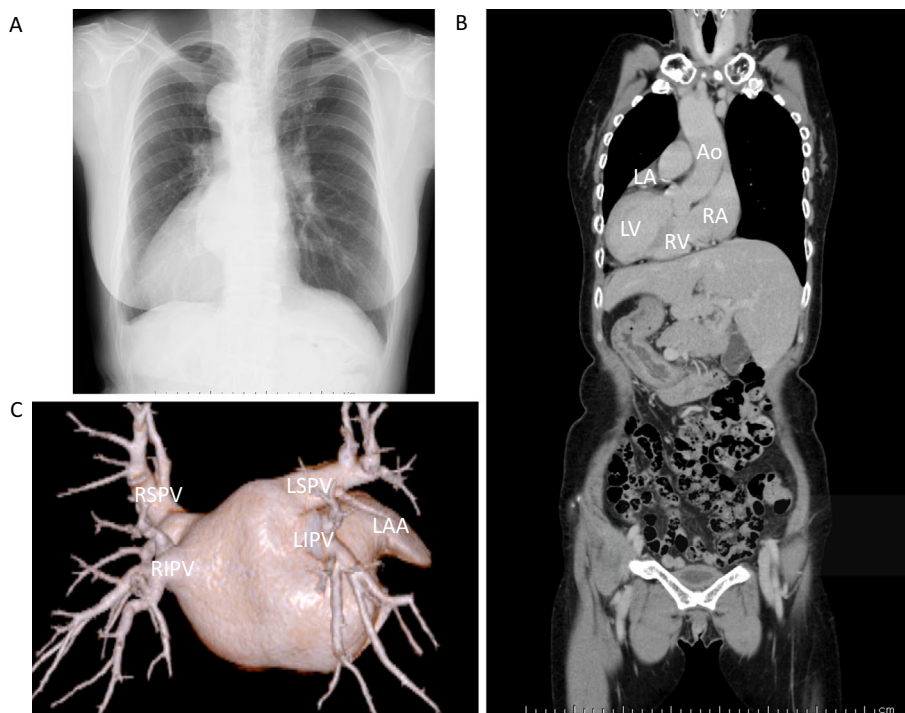


Figure 2. A: Chest X-ray in the frontal view. B: CT images in the sagittal view. C: The left atrium reconstruction anatomy of CT images in posterior-anterior view. Ao: aorta, RA: right atrium, LA: left atrium, RV: right ventricle, LV: left ventricle, LAA: morphologic left atrial appendage, LSPV: morphologic left superior pulmonary vein, LIPV: morphologic left inferior pulmonary vein, RSPV: morphologic right superior pulmonary vein, RIPV: morphologic right inferior pulmonary vein

Ablation Catheter; Abbott Laboratories, Chicago, USA).

Four months after her discharge, atrial tachycardia recurred (AT2, Fig. 1B). ECG with reversed right and left side leads indicated that the cycle length of AT2 (260 ms) was different from that of AT1 (200 ms). We performed catheter

ablation a second time using a three-dimensional electroanatomic mapping system (CARTO3; Biosense Webster Johnson and Johnson, Irvine, USA). We confirmed that there were no reconnections at any of the four PVs and the CTI block line. The post-pacing interval upon entrainment of AT

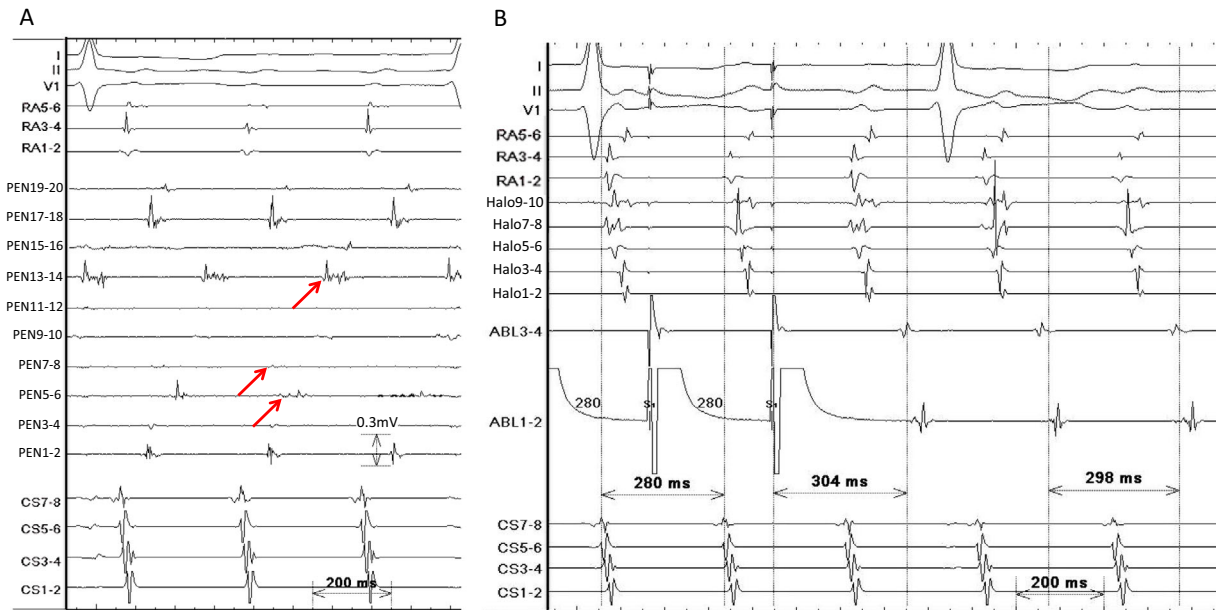


Figure 3. A: Electrograms obtained by the PentaRay catheter (PEN) during AT4. Fractionated low-amplitude potentials (straight red arrows) were recorded at the anterior morphologic left atrium (LA). Electrograms sampled around this area covered the full cycle length of AT4. The electrograms obtained by the PentaRay catheter were enlarged 32-fold. The right atrium (RA; 5-6 proximal and 1-2 distal) and the coronary sinus (CS; 7-8 proximal and 1-2 distal) are shown from top to bottom at a paper speed of 100 mm/s. B: Post-pacing interval evaluated by ablation catheter at the anterior morphologic LA. The post-pacing interval was nearly equal to the cycle length of AT4. A multipolar catheter (Halo; 9-10 proximal and 1-2 distal) was located at RA.

2 at the lateral and roof of the morphologic LA were nearly equal to the tachycardia cycle length. We diagnosed AT2 as LA roof-dependent, and liner ablation of the morphologic LA roof resulted in prolongation of the tachycardia cycle length from 260 to 316 ms (AT3). Because the post-pacing interval upon entrainment of AT3 at the lateral morphologic LA and anterior LA still matched the tachycardia cycle length, we diagnosed AT3 as a mitral flutter. AT3 was rotating around the mitral valve in a counterclockwise direction. Liner ablation between the mitral annulus and left inferior PV resulted in sequence changes in the electrocardiogram at the coronary sinus catheter with shortening of the tachycardia cycle length from 316 to 282 ms (AT4).

We obtained an activation map of AT4 using a PentaRay catheter (Biosense Webster Johnson and Johnson). Fractionated low-amplitude potentials were densely located in a limited area of the anterior morphologic LA (Fig. 3A), and electrograms sampled around this area covered the full cycle length of AT4. An activation map demonstrated the possible presence of small-circuit reentry with an extremely slow conduction at the anterior morphologic LA (Fig. 4B). After we confirmed that the post-pacing interval measured at the anterior morphologic LA approximated the tachycardia cycle length (Fig. 3B), a single energy application targeting the fragmented potentials successfully terminated AT4. After energy applications to the area where the fractionated potentials were recorded, no more atrial arrhythmias were induced. The patient has remained free from any arrhythmias

and heart failure for three years.

Discussion

Catheter ablation in patients with situs inversus totalis can be challenging due to the abnormal location of the heart. Because both cryoballoon ablation and three-dimensional electroanatomic mapping using a multipolar mapping catheter with small, closely spaced electrodes offer different strengths, the selection of an appropriate strategy is important for treating refractory arrhythmia in cases with a complex anatomy.

Dextrocardia with situs inversus is the most common type of dextrocardia in the general population, and IVC continuity with the azygos vein is seen in 0.6% of patients with congenital heart disease (4). In general, complex anomalies involving the heart and the great vessels are rare in dextrocardia with situs inversus totalis compared to isolated dextrocardia and dextrocardia associated with situs ambiguus. Because our patient had no minor anomalies except for polysplenia, we considered situs inversus totalis not to have contributed to the development of pathophysiological changes.

There have been several case reports of successful PV isolation using cryoenergy in patients with situs inversus totalis (5). A single-shot method using a cryoballoon can simplify the procedure and requires less fine-catheter manipulation than conventional tipped catheters. At the first session

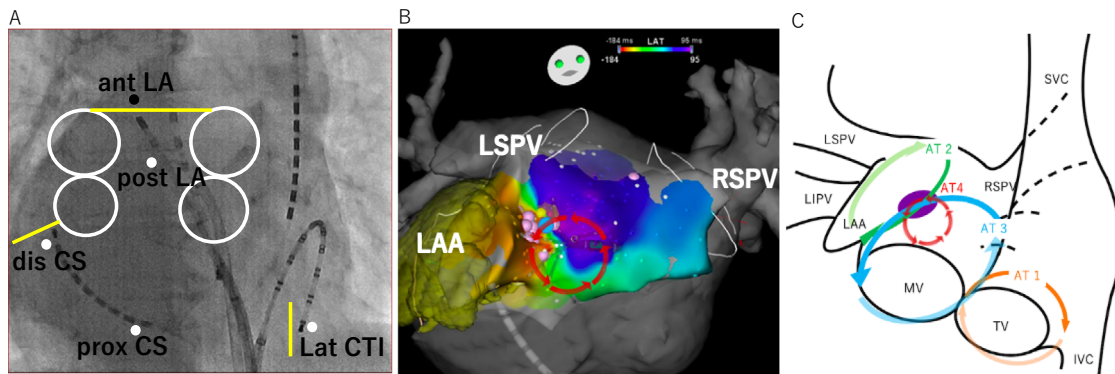


Figure 4. A: Fluoroscopic view of the right anterior oblique (RAO) 50°. Diagnostic catheters were placed in the coronary sinus (CS) and morphologic right atrium (RA), and a temperature probe was located in the esophagus. White circles indicate the pulmonary vein isolation line created by the cryoballoon. Yellow lines indicate linear ablation of the cava-tricuspid isthmus, morphologic left atrium (LA) roof, and mitral isthmus. The black dot indicates the entrainment-pacing site at the anterior morphologic LA (ant LA) where the post-pacing interval (PPI) was approximately equal to the cycle length (CL). The white dots indicate entrainment-pacing sites. lat CTI=lateral cava-tricuspid isthmus (PPI=CL+176 ms), prox CS=proximal coronary sinus (PPI=CL+76 ms), dis CS=distal coronary sinus (PPI=CL+138 ms), post LA=posterior morphologic left atrium (PPI=CL+234 ms). B: Activation map of AT4. The red arrow indicates the possible presence of small-circuit reentry with an extremely slow conduction. The pink dots indicate the points recorded fractionated potentials. The yellow dot indicates the entrainment-pacing site where the PPI was approximately equal to the cycle length. The blue dot indicates the point of successful ablation. The position of the PentaRay catheter indicates where the electrograms shown in 3A were recorded. LAA: morphologic left atrial appendage, LSPV: morphologic left superior pulmonary vein, RSPV: morphologic right superior pulmonary vein. C: Schematic illustration of the reentrant circuits of ATs. The speculated atrial activation sequences are indicated by arrows. AT1 (orange arrows) might be CTI-dependent flutter, as suggested by its cycle length (200 ms). AT2 (green arrows) was morphologic LA roof-dependent flutter (cycle length 260 ms). AT3 (blue arrows) was rotating around the mitral valve in a counterclockwise direction (cycle length 316 ms). AT4 (red arrows) has a localized circuit at the anterior morphologic LA (cycle length 282 ms). LAA: morphologic left atrial appendage, LSPV: morphologic left superior pulmonary vein, LIPV: morphologic left inferior pulmonary vein, RSPV: morphologic right superior pulmonary vein, TV: tricuspid valve, MV: mitral valve, SVC: superior vena cava, IVC: inferior vena cava

in our case, we selected cryoballoon ablation and liner radiofrequency ablation of CTI without mapping in order to simplify the procedure, although her morphologic LA was enlarged. Although we did not perform an electrophysiological study for AT1 and the 12-lead ECG findings were recorded only with normal electrode positions at the previous hospital, we considered AT1 to be CTI-dependent because the cycle length (200 ms) and findings of 12-lead ECG were in accordance with a CTI-dependent atrial flutter.

There have been few reports on complex procedures of radiofrequency ablation in patients with situs inversus totalis (6). At the second session, we used three-dimensional electroanatomic mapping not only to diagnose AT but also to understand the anatomy easily and correctly. A multipolar mapping catheter with small, closely spaced electrodes is useful for detecting fine electrograms with small amplitudes and fractionation (7) and improves the mapping resolution within areas of low voltage. Because the tip of the PentaRay catheter is soft, the risk of cardiac tamponade is low, even in cases with an unusual anatomy. Furthermore, the CARTO3

mapping system provides highly accurate catheter positioning and geometric rendering by magnetic technology (6, 8, 9). In our case, the PentaRay catheter successfully and safely revealed the possible presence of small-circuit reentry with an extremely slow conduction at the anterior morphologic LA. The PentaRay catheter's spine is roughly 1.5 cm wide, so the possible pathway is estimated to be within the 3-cm diameter. These technologies can facilitate the successful ablation of refractory arrhythmia in cases with a complex anatomy.

Several limitations associated with the present study warrant mention. First, in order to simplify the procedure, we did not perform either three-dimensional activation mapping or voltage mapping of whole chamber about any atrial arrhythmias. If we had obtained whole mapping of AT2 at first, we might have been able to identify the critical common isthmus of multiple arrhythmias at the anterior morphologic LA. In addition, the reentrant circuits shown in the schematic illustration of ATs in Fig. 4C are only speculation, as we did not obtain enough points to map the entire

circuit. The results of entrainment pacing of AT4 are shown in Fig. 4A, but we were only able to perform one pacing attempt on the circuit of reentry. Finally, inductions of AF triggers using isoproterenol before and after PV isolation were not conducted.

The authors state that they have no Conflict of Interest (COI).

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