

Combining with Intracardiac Echocardiography and Radiofrequency Catheter Ablation of Focal Right Atrial Tachycardia in Dextrocardia: Challenge and Literature Review

Yankai Guo¹, Shuai Shang¹, Guiqiu Cao¹, Jiasuoer Xiaokereti¹, Zu Ke-la Tu Er-hong¹, Xu Yang¹, Ling Zhang¹, Yan-mei Lu¹, Jiang-Hua Zhang¹, Qiang Xing¹, xianhui zhou¹, Yuanzheng Ye¹, Tianheng Sun¹, Yao-Dong Li¹, and Baopeng Tang¹

¹Xinjiang Medical University Affiliated First Hospital

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Abstract

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Yankai Guo ^{1, 2#}, Shuai Shang ^{1, 2#}, Guiqiu Cao ³, Jiasuoer·Xiaokereti^{1, 2}, Zu Kela Tu Erhong ^{1, 2}, Xu Yang ^{1, 2}, Ling Zhang ², Yanmei Lu^{1, 2}, Jianghua Zhang ^{1, 2}, Qiang Xing ^{1, 2}, Xianhui Zhou ^{1, 2}, Yuanzheng Ye ^{2, 4}, Tianheng Sun ^{1, 2}, Yaodong Li ^{1, 2} (co-corresponding author), and Baopeng Tang ^{1, 2}(corresponding author)

Affiliations:

¹Department of Pacing and Electrophysiology, The First Affiliated Hospital of Xinjiang Medical University, Urumqi 830000, Xinjiang, China.

²Department of Cardiac Electrophysiology and Remodeling, The First Affiliated Hospital of Xinjiang Medical University, Urumqi 830000, Xinjiang, China.

³Department of Cardiology, The Fifth Affiliated Hospital of Xinjiang Medical University, Urumqi 830000, Xinjiang, China.

⁴Department of Cardiac Function, The First Affiliated Hospital of Xinjiang Medical University, Urumqi 830000, Xinjiang, China.

Yankai Guo and Shuai Shang contributed equally to this work.

*Corresponding Author:

Baopeng Tang ^{1, 2}, PhD, FESC, FHRS, FEHS (corresponding author).

Yaodong Li ^{1,2}, PhD (co-corresponding author).

¹Department of Pacing and Electrophysiology, The First Affiliated Hospital of Xinjiang Medical University, No.137, South Liyushan Road, Xinshi Zone, Urumqi, Xinjiang, China.

²Department of Cardiac Electrophysiology and Remodeling, The First Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang, China.

Email:

tangbaopeng1111@163.com, boylyd@163.com

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Introduction

Dextrocardia is a mirror image right-sided heart with congenital heart position malformation associated with abnormal embryonic development, unusual organ position transposition, other internal organs inversion, etc. The incidence is low in the population, only 1/10,000-12,000¹. Patients with dextrocardia usually have no specific health problems, but are more likely to suffer from cardiovascular, esophageal, intestinal, and bronchial diseases than the general population².

Atrial tachycardia is a common type of atrial arrhythmia that originates in the atria and does not require the participation and maintenance of the atrioventricular node. The atrial frequency during atrial tachycardia attacks is mostly 150-200 beats/min³. The incidence of atrial septal aneurysm is about 2.4%⁴. Previous studies suggest that the incidence of atrial arrhythmias is about 15% in adult patients with congenital heart disease, and the incidence of atrial tachycardia is even lower in patients with dextrocardia and atrial septal aneurysm, which has rarely been reported⁵. Because of the anatomical abnormalities of the heart and blood vessels in patients with dextrocardia, ablation of arrhythmias is more complex than regular patients, and cannot effectively guarantee safety.

Intracardiac echocardiography (ICE) is an advanced imaging method in electrophysiological procedures. Combined electroanatomical mapping systems can guide catheter ablation in complex anatomical conditions. ICE facilitates the visualization of the evaluation of the catheter positioning, which better assists operator in gaining a comprehensive understanding of the variable cardiac structures and effectively guarantees the safe performance of the procedure^{6,7}.

This article reports a case of successful radiofrequency ablation of atrial tachycardia in a patient with dextrocardia and atrial septal aneurysm in combination with intracardiac echocardiography, and summarizes the relevant experience.

Case report

A female patient, 66 years old, was admitted to the hospital with the chief complaint of "intermittent palpitation accompanied by chest tightness for 11 years, aggravated for 1month". Previous history of hypertension for 3 months and coronary artery disease for 1 month.. 12-lead ECG (Figure 1A) indicates sinus rhythm, 24h ambulatory ECG indicates atrial tachycardia (narrow QRS tachycardia). Chest radiographs (Figure 1B) and cardiac CTA (Figure 1D) suggest dextrocardia and atrial septal aneurysm. The echocardiogram (Figure 1C) showed the patient had a mirror dextrocardia, right aortic arch, left atrium 34 mm, left ventricular diastolic 47 mm, and right atrium 35 mm. Transesophageal echocardiography showed no thrombus formation in the left atrial appendage, which was thinner in the middle of the atrial septum between the left and right atrial, and expanded to the right atrial side, with a maximum depth of about 17mm. Conventional 12-lead ECG and CTA of the left atrial pulmonary vein simultaneously suggested dextrocardia (Figure 1). The patient had

been taking medication, but the medication was ineffective. Transcatheter cardiac radiofrequency ablation was performed with the consent of the patient and his family.

The patient was lying flat on the operating table, electrocardiogram, blood pressure and oxygen monitoring, the operating area was routinely disinfected and towed, 2% lidocaine was used to locally infiltrate the puncture area and after the anesthesia took effect, the right femoral vein was punctured and an 11F sheath was placed, the ultrasound probe was sent along the 11F sheath to the middle of the right atrium to clarify the special spatial structure of the heart, whether there was thrombosis in the left atrial appendage, and to guide the atrial septal puncture as follows (Figure 2). The left and right femoral veins were then punctured, and a 6F sheath was placed on the left side and a 7.5F sheath on the right side. A 10-pole electrode was placed in the coronary sinus through the left venous sheath under fluoroscopy, and a 4-pole electrode was placed in the right ventricular apex through the right femoral vein. Electrophysiological examination: S1S1 stimulating was administrated to CS 7-8, Wenckebach point was 280ms, once S1S1 was decreased to 210ms, narrow QRS tachycardia was induced. The earliest atrial activation was measured in CS 7-8, TCL was 310ms, with 1:1 atrioventricular conduction. Further entrainment with RV S1S1 290ms was administrated, the interval of atrioventricular remained the same, the cycle length of A-A interval was still 310ms, indicating the arrhythmia was atrial tachycardia. Then the ablation head was sent to the right atrium through the venous sheath for high-precision mapping. The results showed that the earliest activation point of the right atrium was located near the His bundle, suggesting that the earliest activation point of the right atrium was not from the right atrium. This leads one to consider whether the origin of the earliest activation is from the anatomically adjacent region, such as the left atrium and non-coronary sinus. Further atrial septal puncture was required, because the patient was complicated with atrial septal aneurysm. The difficulty and risk of atrial septal puncture will be greatly increased in dextrocardia if only traditional image positioning was used for atrial septal puncture, which further reflects the importance of ICE. Under the guidance of ICE, we fully reconstructed the structure of the left atrium, and selected the weaker middle part of the atrial septum for puncture (figure). After success, a multi-electrode mapping catheter was used to perform high-precision mapping of the left atrium under atrial tachycardia. The mapping results indicated that the anterior septum of the left atrium and the aortic indentation were the earliest activation areas, which is adjacent to the earliest area of the right atrium, and the activation time is about 30ms ahead of the earliest right atrium, and the local activation time is 55ms ahead of the reference zero point (Figure). Attempt to ablate with a power mode of 30W, the atrial tachycardia has not been terminated, suggesting that the ablation was ineffective, consider mapping anatomically adjacent parts: no coronary sinus. The right femoral artery was punctured, and the earliest activated conduction potential was traced at the bottom of the non-coronary sinus, and the local activated time was 80ms ahead of the reference zero point. Titrated ablation in the power mode of 25-40W, the atrial tachycardia was terminated immediately after ablation, the patient recovered sinus rhythm, and the ablation was consolidated for 60 seconds. No junctional rhythm and prolongation of the atrioventricular interval were observed during the ablation process (Figure). After the ablation, repeating the previous induction conditions and repeated high-frequency atrial and coronary sinus stimulation did not induce any form of arrhythmia. Intracardiac ultrasonography was used to detect the pericardium, and the operation ended after confirming safety. At 3-month postoperative follow-up, the patient's panic symptoms disappeared and no atrial tachycardia was seen on the repeat ambulatory electrocardiogram.

Discussion

Dextrocardia is a rare congenital condition with an incidence of about 1 in 10,000¹, the incidence of atrial septal aneurysm is about 2.4%⁴, and the combination of arrhythmias is even rarer, making catheter ablation more difficult due to its anatomical variants, combined with abnormal pulmonary venous connections or other visceral transposition^{1,2}. This article exhibits a case of a female patient with dextrocardia combined with atrial septal aneurysm and focal atrial tachycardia who underwent successful radiofrequency ablation.

In this case, the patient had focal atrial tachycardia and atrial septal aneurysm, and congenital dextrocardia at the same time, which brought great challenges to our radiofrequency ablation. Fortunately, we successfully and safely completed the radiofrequency ablation procedure and summarized as follows, 1) In patients with

dextrocardia undergoing atrial tachycardia, a thorough preoperative evaluation to understand the specific structural variants of the heart is essential, such as cardiac ultrasound and cardiac enhancement CT, which help the operator to perform a thorough preoperative evaluation and formulate an effective ablation strategy, reduce the number of unnecessary punctures and operations, shorten the procedure time and ensure the safety of the procedure. 2) Because the position of the atrium of patients with dextrocardia is opposite to that of ordinary people, the right anterior oblique position and the left anterior oblique position should to be exchanged during fluoroscopy, which is different from the fluoroscopy position of our normal patients. Better assessment of the condition and revision of surgical strategies during surgery. 3) ICE is an advanced application in electrophysiological surgery that can provides real-time imaging modalities with spectral and color Doppler capabilities, integrate directly with electroanatomical mapping systems, can visualize complex anatomical structures, allowing the operator to develop individual ablation strategies, thereby avoiding ineffective ablation and/or reducing the occurrence of surgical complications⁸. In this case, we administered ICE before performing ablation. On the one hand, confirming that there is no thrombosis in the left atrial appendage, which is the premise of safe operation. On the other hand, a better understanding the special heart structures can guide atrial septal puncture, especially in the presence of an atrial septal aneurysm, and better reaching the designated ablation site. 4) The CARTO 3D imaging system is an important part of the intraoperative procedure, which allows for effective 3D reconstruction of the cardiac structure before ablation, helping the operator to understand the spatial structure of the heart better and improving the safety and effectiveness of intraoperative catheterization. 4) For patients who failed atrial tachycardia radiofrequency ablation in conventional locations, attention should also be paid to non-conventional ablation sites such as the non-coronary sinus during intraoperative electrical activation mapping.

Antiarrhythmic drugs and transcatheter cardiac radiofrequency ablation are the conventional treatment modalities for atrial tachycardia. With the growing experience of transcatheter cardiac radiofrequency ablation, the procedure's success rate has improved significantly over the past few years. Catheter radiofrequency ablation is routinely performed in experienced centers and, given the side effects of antiarrhythmic drugs, which has become the treatment of choice for atrial tachycardia. However, the anatomical variation of cardiac structure in patients with dextrocardia is still not well known, let alone the presence of atrial septal aneurysm, so the difficulty of successful ablation will undoubtedly be further increased if arrhythmias are concomitant, which has rarely been reported so far.

In 1994, Wu et al¹⁰ first reported catheter radiofrequency ablation of a patient with a mirrored dextrocardia and persistent atrioventricular reentrant tachycardia. The procedure was successful and without complications, demonstrating the feasibility of radiofrequency ablation in treating patients with dextrocardia. Vaseghi et al¹¹ reported a patient with mirror-image dextrocardia combined with counter-clockwise atrial flutter in the right atrial, of which the tachycardia was cured by ablation of the tricuspid-inferior vena cava isthmus, the application value of ECG in guiding the ablation of patients with dextrocardia complicated with arrhythmia is also proposed at the same time. Benjamin et al¹² proposed in the radiofrequency ablation of patients with dextrocardia complicated with atrial fibrillation and atrial flutter, the use of CARTO for electroanatomical localization of the right atrium, combined with intracardiac echocardiography and fluoroscopy for atrial septal puncture, is helpful for the operator better judge the opposite anatomical position, improving the accuracy and success rate of the operation. Vurgun et al¹³ reported the first case of catheter ablation of scar-associated atrial flutter due to surgical repair of atrial septal defects with dextrocardia and complex venous anomalies. They placed three long sheaths through the femoral vein at the superior vena cava and right atrium to stabilize and control the catheter. Activation mapping with Carto-3D system suggested that the tachycardia spread between the two scars. Tachycardia stops when linear ablation is performed between two scars, demonstrating that radiofrequency ablation with an electroanatomical mapping system is effective and safe in such patients. Zhang et al¹⁴ reported 19 patients with dextrocardia and arrhythmia who underwent successful transcatheter cardiac radiofrequency ablation, demonstrating that radiofrequency ablation is safe, effective, and feasible in such patients. Combining echocardiography, cardiac computed tomography, and 3D mapping, the application of 3D reconstruction can improve the success rate of catheter ablation. Zhou et al¹⁵ reported 10 patients with dextrocardia and arrhythmias undergoing catheter ablation, including atrioventric-

ular nodal reentrant tachycardia, atrioventricular reentrant tachycardia, intra-atrial reentrant tachycardia, and focal atrial atrial fibrillation. Among them, 9 cases were immediately successful during the operation, and no operative complications occurred. All patients were followed up for 6.3 +- 3.5 years without any arrhythmia recurrence. Proposing that paying attention to the anatomical abnormality of the dextrocardia and the cardiac structure, as well as the adjacent relationship of the surrounding structures, is the key to the success of catheter ablation, and recommending setting the ECG leads in a mirror mode, and invert the fluoroscopic image horizontally, which is conducive to the understanding of intraoperative anatomical positioning. In recent years, in addition to radiofrequency ablation, balloon cryoablation has also been used to treat arrhythmias in patients with dextrocardia. Akkaya et al¹⁶ reported the first case of cryoballoon ablation in a patient with focal atrial tachycardia in dextrocardia. The successful ablation of abnormal potentials originating in the superior pulmonary vein inferior to the ramus under the guidance of the En-site system suggests that cryoballoon ablation may also be safe and feasible in patients with dextrocardia combined with arrhythmias.

In summary, the key to successful catheter ablation in patients with dextrocardia, atrial septal aneurysm, and arrhythmia lies in the preoperative comprehensive analysis of the patient's examination data to develop a surgical strategy that will lead to faster and better access to the procedure. Necessary preoperative tests include electrocardiogram, echocardiography, and cardiac CTA. During the operation, ICE, fluoroscopic image, and Carto three-dimensional mapping system can be combined to guide catheter positioning better and adjust catheter operation to ensure smooth operation and reduce operation time and complications. Adequate preoperative evaluation, meticulous intraoperative electrophysiological examination and mapping, and the use of the latest assistive technologies are prerequisites for ensuring the safe and effective operation of surgery, and each operator needs to take it seriously.

First Author	Reference	Year	Article Type	Patient Type
Wu TJ	[10]	1994	Case Reports	dextrocardia, atrial septal defect, drug-refractory atrial tachycardia
Vaseghi M	[11]	2005	Case Reports	complete situs inversus, Counterclockwise atrial flutter
Benjamin MM	[12]	2015	Case Reports	Situs inversus totalis, atrial flutter, atrial fibrillation
Vurgun VK	[13]	2018	Case Reports	dextrocardia, scar-related atrial flutter, inferior vena cava interruption
Zhang Y	[14]	2022	Original Article	dextrocardia, fourteen cases had atrial fibrillation, seven had atrial flutter
Zhou GB	[15]	2019	Multicenter Study	dextrocardia and situs inversus, supraventricular tachycardia (SVT)
Akkaya E	[16]	2019	Case Reports	focal atrial tachycardia in a patient with situs inversus and dextrocardia

Table 1. Literature summary of catheter ablation in dextrocardia.

Figure 1 Examination suggests that the patient has a dextrocardia. A) Electrocardiogram showing dextrocardia with limb reversal in I and avR. B) Chest radiograph showing apex pointing to the right. C) and D) Echocardiograph and coronary CTA showing mirror dextrocardia, right aortic arch. RA, right atrial; RV, right ventricular; LA, left atrial; LV, left ventricular; AO, aorta.

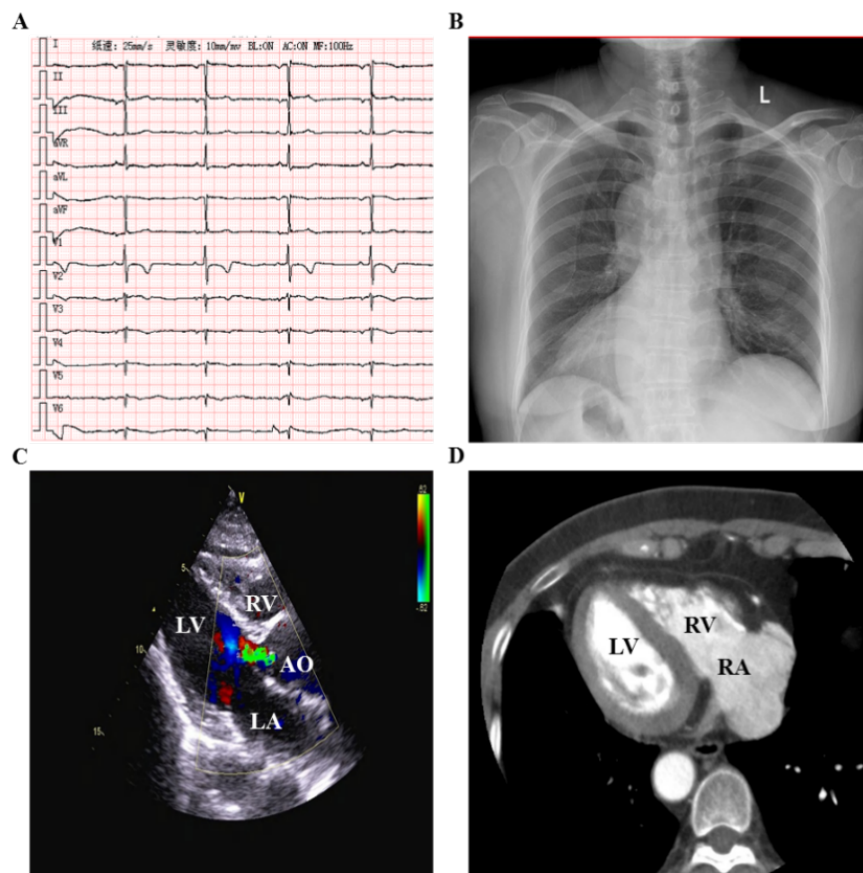


Figure 2 Intracardiac echocardiography-guided atrial septal puncture and detection of left atrial appendage thrombus in mirror dextrocardiac. RA, right atrial; RV, right ventricular; LA, left atrial; LV, left atrial; LAA, left atrial appendage; FO, Fossa ovalis.

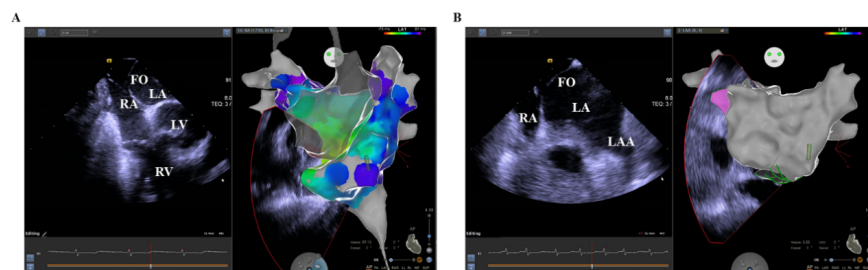
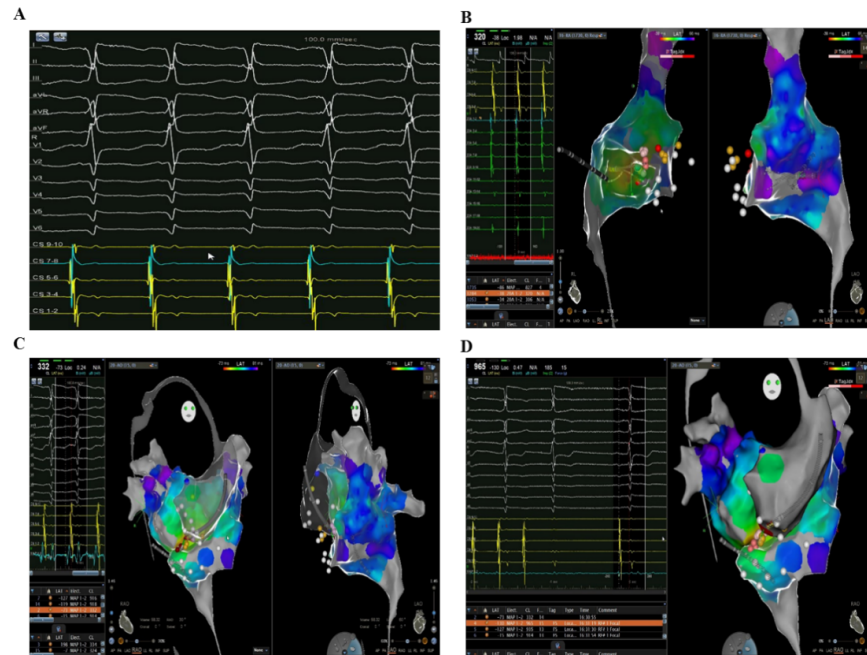


Figure 3 Ablation strategies in mirror dextrocardia. A) Intracavitary electrograms suggest that coronary sinus 7-8 activations is the earliest. B) Right atrial excitation mapping suggests that the earliest activation point is referenced 38 ms in advance. C) Non-coronary sinus excitation mapping suggests that the earliest excitation point is referenced 73 ms in advance. D) Atrial tachycardia terminated in 2s after radiofrequency was started in Non-coronary sinus.



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