

Catheter Ablation Effects on Focal Atrial Tachycardia Mistaken for Sinus Tachycardia: A Report of Three Cases

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Abstract

Purpose: To present the clinical, functional outcomes of radiofrequency ablation in three cases of focal atrial tachycardia arising from the right atrial appendage (RAAT).

Method: A retrospective case series reporting the profile, pre-ablation presentation, catheter ablation process and post-ablation outcome of focal atrial tachycardia originating in the right atrial appendage of three patients who had been masquerading as inappropriate sinus tachycardia before ablation. After catheter ablation, three patients had a minimum of three months follow-up. A retrospective analysis was performed to identify two patients with LV dysfunction, defined as an ejection fraction <50% on echocardiography. Recovery of LV function was also assessed.

Results: The patients were one female and two males aged 29, 14 and 54, respectively. All RAAT was confirmed and eliminated successfully with mapping and ablation. Post-ablation electrocardiogram from two cases demonstrated a negative notched P-wave in leads V1 and V2 during RAAT compared with a beat of sinus rhythm and one case remained the same as pre-ablation ECG pattern in P-wave in leads V1 and V2. After successful ablation, LV function was restored in two patients at three months. The symptoms of palpitations and dyspnea were significantly improved in all patients.

Conclusion: RAAT is likely to be misdiagnosed as sinus tachycardia and induce cardiac insufficiency. Long-term restoration of LV function can be achieved after successful catheter ablation of the tachycardia focus.

Keywords: Right atrial appendage tachycardia • Catheter ablation • Tachycardia-mediated cardiomyopathy • Heart failure

Abbreviations: AT: Atrial Tachycardia; CS: Coronary Sinus; ECG: Electrocardiogram; EP study: Electrophysiological Study; RAAT: Focal atrial tachycardia arising from the right atrial appendage; LAO: Left Anterior Oblique; LV: Left Ventricular; LVEF: Left Ventricular Ejection Fraction; NT-proBNP: N-terminal pro Brain Natriuretic Peptide; PACs: Premature Atrial Contractions; RAO: Right Anterior Oblique; RAA: Right Atrial Appendage; RFCA: Radio Frequency Ablation; SA: Sinoatrial Node; SR: Sinus Rhythm; SVT: Supraventricular Arrhythmias; TCM: Tachycardia-mediated Cardiomyopathy; TTE: Transthoracic Echocardiogram

Introduction

Focal atrial tachycardia (AT) arising from the right atrial appendage (RAAT) was often masqueraded /"diagnosis" as sinus tachycardia even inappropriate sinus tachycardia [1,2] and tachycardia-mediated cardiomyopathy (TCM) is an important reversible cause of left ventricular (LV) dysfunction that may complicate endless supraventricular [2]. Catheter ablation is an established treatment for the majority of patients with supraventricular arrhythmias (SVT) with high success rates [3-5]. The purpose of the present study was to describe the electrophysiological characteristics of focal AT from the right atrial

appendage associated with the development of reversible LV dysfunction and the long-term clinical outcome after successful catheter ablation.

Case Presentation

Case 1

A 29-year-old woman had experienced a 4-month history of pregnancy. Because she experienced frequent palpitations and endless tachycardia since pregnancy, then she developed hypotension, the pregnancy was terminated forcibly in the obstetrics department when she was in the fourth month of pregnancy. The patient was diagnosed as pregnant with "sinus tachycardia" in the obstetrics department at first (Figure 1A). Unfortunately, she experienced a different kind of palpitations still after the surgical methods of inducing abortion, which occurred when was sleeping or worsened with activity. A Holter monitor showed premature atrial contractions (PACs) and AT during sleeping and worsened with activity (Figure 1B). She received metoprolol treatment initially; however, the symptoms of palpitations and dyspnea did not improve significantly because of tachycardia. Recently, the palpitations worsened after mild exercise activity and significantly increased disproportionately after resting and metoprolol was ineffective. The patient did not experience symptoms of chest pain or syncope and she had not experienced nausea or heartburn, or gastrointestinal distress. The physical examination and laboratory tests were

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Received: 30 March, 2023, Manuscript No. cmcr-23-97460; **Editor assigned:** 03 April, 2023, Pre QC No. P-97460; **Reviewed:** 13 April, 2023, QC No. Q-97460; **Revised:** 19 April, 2023, Manuscript No. R-97460; **Published:** 28 April, 2023, DOI: 10.37421/2684-4915.2023.7.251

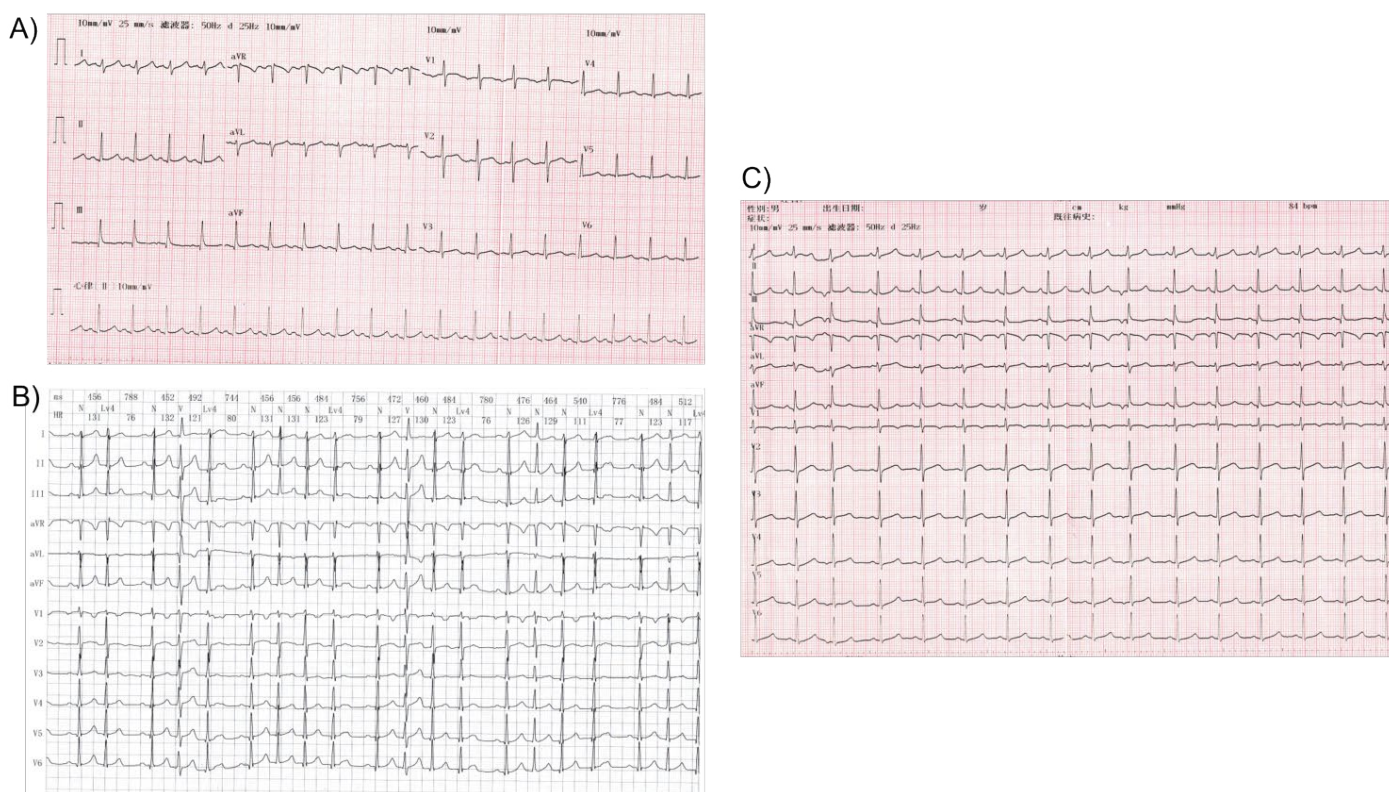


Figure 1. (A) ECG (25mm/s) and 24-hr Holter, (B) during atrial tachycardia at a rate of 90-130 bpm, the P wave pattern was negative in lead V1, and the inferior lead was positive, tachycardia continues to attack endlessly at night and early in the morning and (C) ECG (25mm/s) resumed sinus rhythm at a rate of 83 bpm after RFCA, the P wave pattern was positive and negative directions in lead V1 and V2, and the inferior lead was positive.

normal. However, evidence of left ventricular dysfunction with left ventricular ejection fraction (LVEF) was 38% and enlargement of the right heart system was found by a transthoracic echocardiogram (TTE) in the local county hospital. Because palpitations were seriously affecting the patient's everyday life due to the endless episodes of tachycardia, she was strongly recommended to undergo an invasive electrophysiological study (EP study) and radiofrequency ablation (RFCA).

First, a pulmonary vein mapping electrode (Abbott, America) was used to create a right atrial activation map by EnSite Navx System (Abbott, America) to define the origin of the sustained arrhythmia. For confirmation, we mapped the superior vena cava (SVC), but did not find the earliest activated site. Then, we sent a pulmonary vein mapping electrode into the right atrial appendage (RAA) and created a right atrial activation map (Figure 2A), which showed that the earliest activated site was the RAA but not the sinoatrial node (SA) —the A wave of the bipolar electrogram was ahead of the body surface wave 45 ms. RFCA was performed using an irrigated catheter (TactiCath Ablation Catheter, Abbott, America) with power limits of 43°C and 35 W, respectively. We did not observe a significant vagus bradycardia response during radiofrequency energy delivery. Finally, tachycardia could not be induced by isoproterenol after ablation (Figure 2B). ECG resumed sinus rhythm at a rate of 83 bpm after RFCA, the P wave pattern was positive and negative directions in lead V1 and the inferior lead was positive (Figure 1C). Post ablation, the patient's atrial tachyarrhythmia did not recur and a 3-month Holter monitor recording did not show any tachyarrhythmia despite strenuous exercise.

Case 2

A 54-year-old male was admitted with palpitations, dizziness and fatigue for two years, which worsened for one month. The patient started to experience palpitations, fatigue, dyspnea and dizziness after repeated activities two years ago. The above symptoms have worsened in the past month without any obvious cause. After admission, he was diagnosed with "Sinus tachycardia", cardiac dilatation and heart failure in a local hospital. The N-terminal pro-brain natriuretic peptide (NT-proBNP) value was 3,366 ng/L. TTE showed that the left ventricular was enlarged. The left atrium and ventricle diameter were 35 and 66 mm at the end of the diastole phase, respectively and LVEF was 27%.

The ECG showed "Sinus tachycardia" initially. However, further study reveals that the P wave pattern was negative in lead V1 and the inferior lead was positive and towering, suggesting the origin of the RAA [2], in this case, the ECG was very highly similar to the previous RAA ECG (Figure 3A and 3B). The 24-hr Holter showed persistent atrial tachycardia with variable conduction (2-1:1), a mean heart rate of 100 beats per minute and a maximum heart rate of 125 beats per minute. The use of beta loci to treat "sinus tachycardia" was ineffective in a local county hospital. When he came to our hospital because of "sinus tachycardia" and dyspnea, an invasive EP study and RFCA were recommended.

The standard catheter position was used for EP study in the coronary sinus and his bundle area. Coronary sinus (CS) mapping showed that the atrial activation sequence during atrial tachycardia was proximal to distal. Under the guidance of the three-dimensional mapping system EnSite Navx System (Abbott), the TactiCath Ablation Catheter mapping electrode was used to perform three-dimensional reconstruction and activation mapping of the right atrium. The results of three-dimensional system mapping confirmed that the earliest atrial excitatory site was located in RAA (Figure 3D). In this area, the surgeon used the Therapy™ Cool Flex™ ablation catheter (Abbott, USA) to meticulously map the earliest activation point—the A wave of the bipolar electrogram was ahead of the body surface wave 79 ms and the unipolar electrogram showed a QS pattern. The ablation was successfully performed, setting the power as 30 Watt (W), the temperature as 43°C, the saline perfusion rate as 17 ml/min and the ablation time as 30–60 s at each ablation point. The entire base of the right atrial appendage was performed by radio frequency injuries in a total of 40 min.

The patient's atrial tachycardia was terminated and returned to sinus rhythm (SR) and the heart rate immediately went from 140 to 75 beats/min after the operation (Figure 3E). After the operation, the patients took Shakubartrum valsartan and spironolactone tablets. The patient did not feel palpitations and Holter detected no arrhythmia during the 3-month follow-up period after RFCA and the heart structure gradually returned to normal. The chest radiograph showed that the cardiothoracic shrinkage to normal compared with the preoperative. The TTE showed the diameter of the left atrium and ventricle were 35 and 54 mm, respectively and the LVEF was 68%.

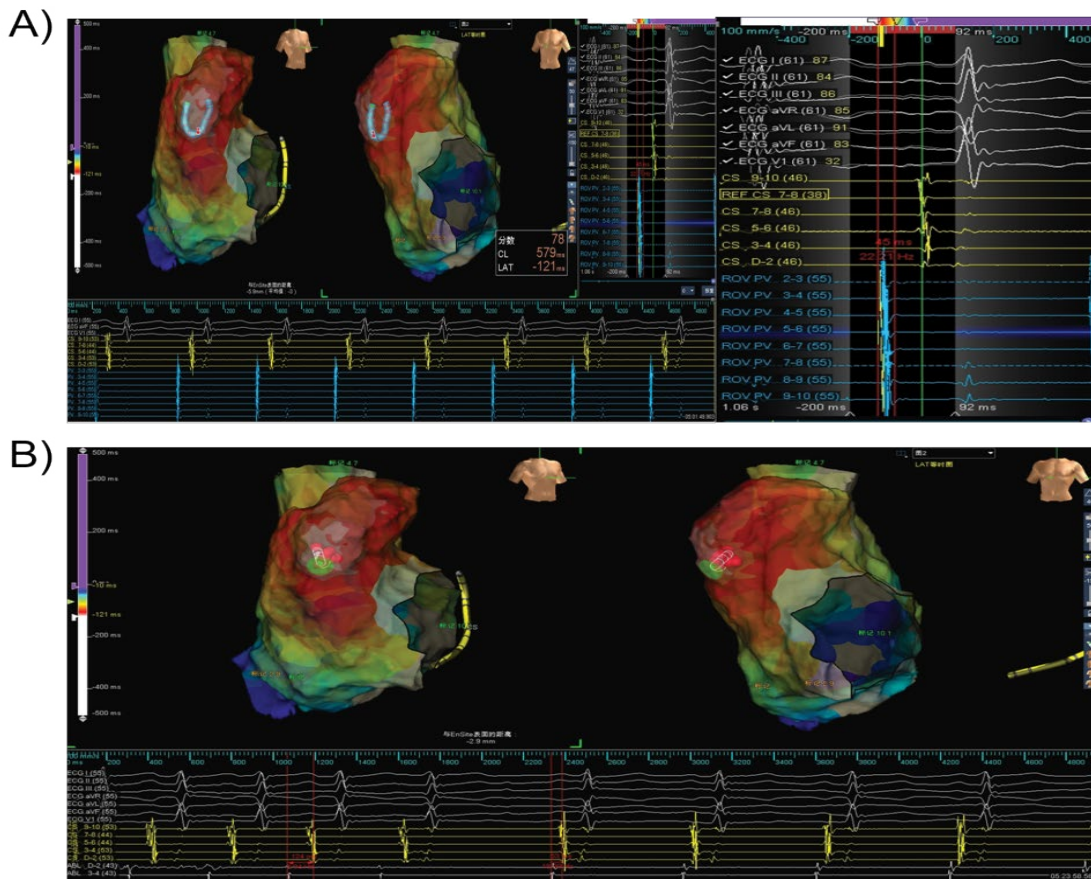


Figure 2. (A) Right atrium from activation mapping (EnSite-NavX) in Right anterior oblique (RAO) and Left anterior oblique (LAO) view. Activation at the apex of the RAA is the earliest—the A wave of the bipolar electrogram was ahead of the body surface wave 45 ms and (B) Catheter position for RAA ablation: Atrial tachycardia was terminated and resumed sinus rhythm by using an irrigated catheter.

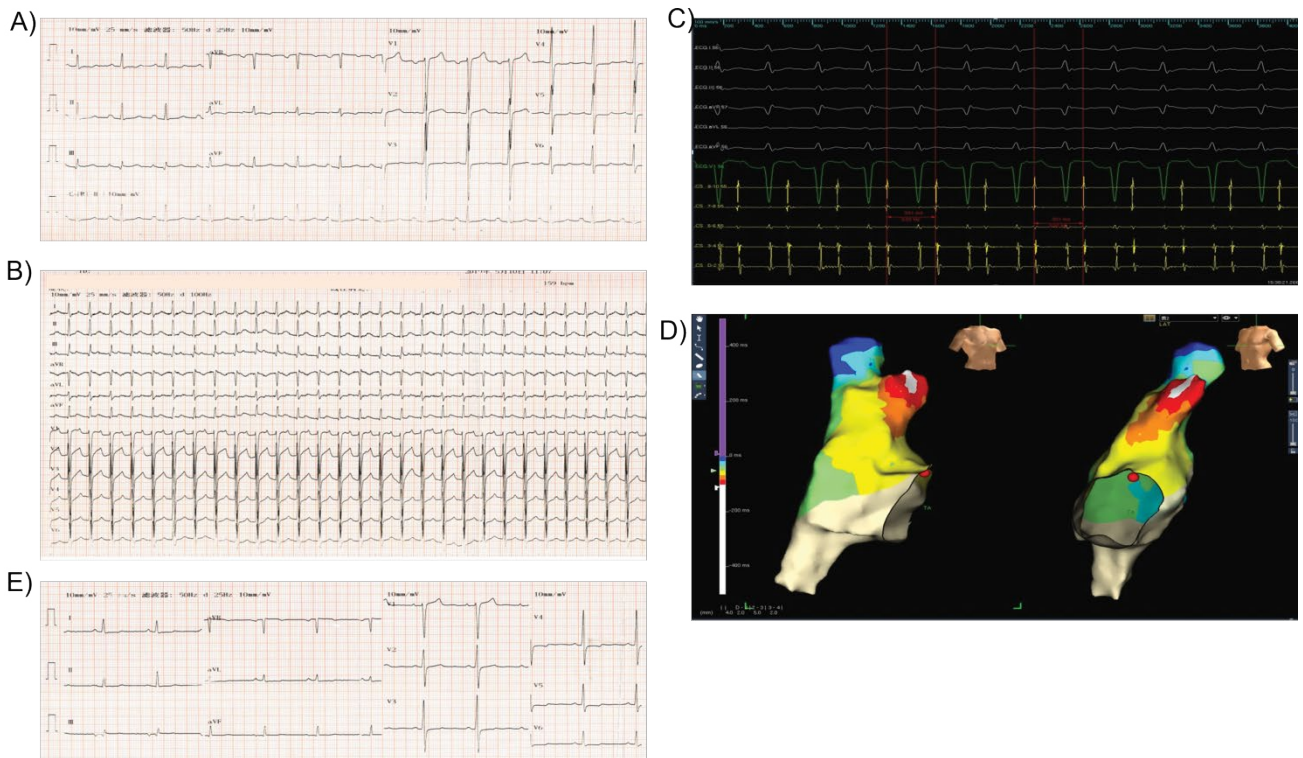


Figure 3. (A) ECG (25mm/s) for atrial tachycardia at a rate of 80 bpm, the P wave pattern was negative in lead V1, and the inferior lead was positive, (B) Synchronous lead electrocardiogram (25mm/s) for atrial tachycardia at a rate of 160 bpm, (C) Atrial tachycardia circumference was measured with 331ms, which was consistent with clinical tachycardia, (D) Right atrium from activation mapping (EnSite-NavX) in RAO and LAO view. Activation at the apex of the RAA is the earliest—the A wave of the bipolar electrogram was ahead of the body surface atrial wave 79 ms and (E) ECG (25mm/s) resumed sinus rhythm after RFCA at a rate of 83 bpm, the P wave pattern was positive in lead V1 and V2, the inferior lead was positive.

Case 3

A 14-year-old boy presented to our clinic with palpitation and shortness of breath. He underwent the discomfort of repeated palpitations a year ago, "sinus tachycardia was diagnosed and metoprolol was given orally at the local county hospital. However, he had to drop out of school because of repeated palpitations. The ECG showed "Sinus tachycardia" initially (Figure 4A). In addition, transesophageal pacing can perform entrainment atrial but not terminate tachycardia (Figure 4B). The Holter showed continuous "Sinus tachycardia", which is a mean heart rate of 120 beats per minute and a maximum heart rate of 126 beats per minute. EP study and RFCA were recommended ultimately.

First, an irrigated catheter (TactiCath Ablation Catheter, Abbott) was used

to create a right atrial activation map using EnSite Navx System (Abbott) to define the origin of the sustained arrhythmia. For confirmation, we mapped the superior vena cava (SVC) and coronary sinus (CS), but did not find the earliest activated site. Then, we sent irrigated catheter into the right atrial appendage (RAA) and created a right atrial activation map (Figure 5A), meanwhile, RAA angiography was performed by irrigated catheter (Figure 5B), which confirmed that the earliest activated site was the RAA. This indicated that the earliest activated site during induced AT was in the RAA with temperature and power limits of 43°C and 35 W, respectively. We did not observe a significant vagus bradycardia response during radiofrequency energy delivery. Finally, tachycardia could not be induced by isoproterenol after ablation. Post ablation, the patient's atrial tachyarrhythmia did not recur and a 3-month and 7-year

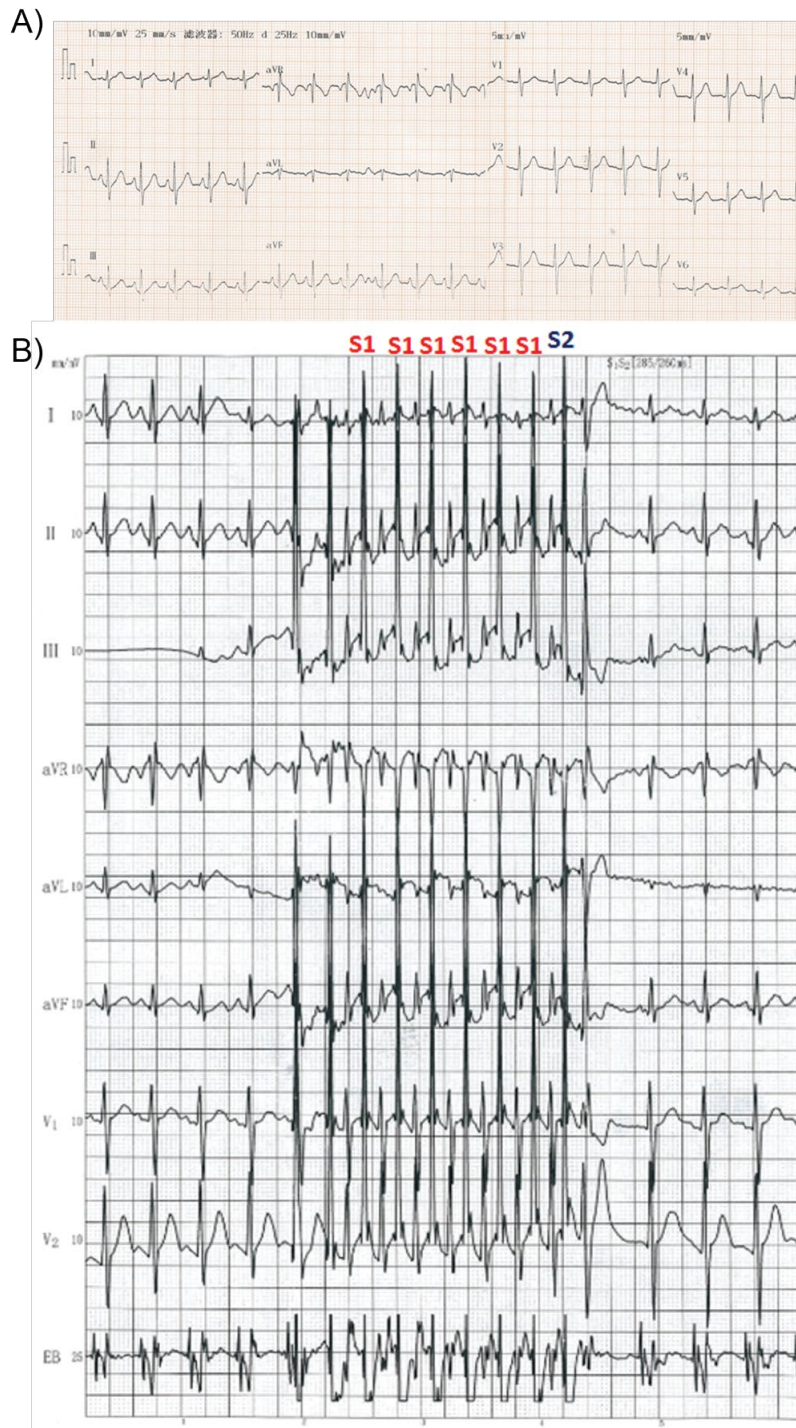


Figure 4. (A) ECG (25mm/s) during atrial tachycardia at a rate of 126bpm before RFCA and **(B)** Trans esophageal pacing could not terminate tachycardia (stimulus method: S1S2=285/250ms, 25mm/s).

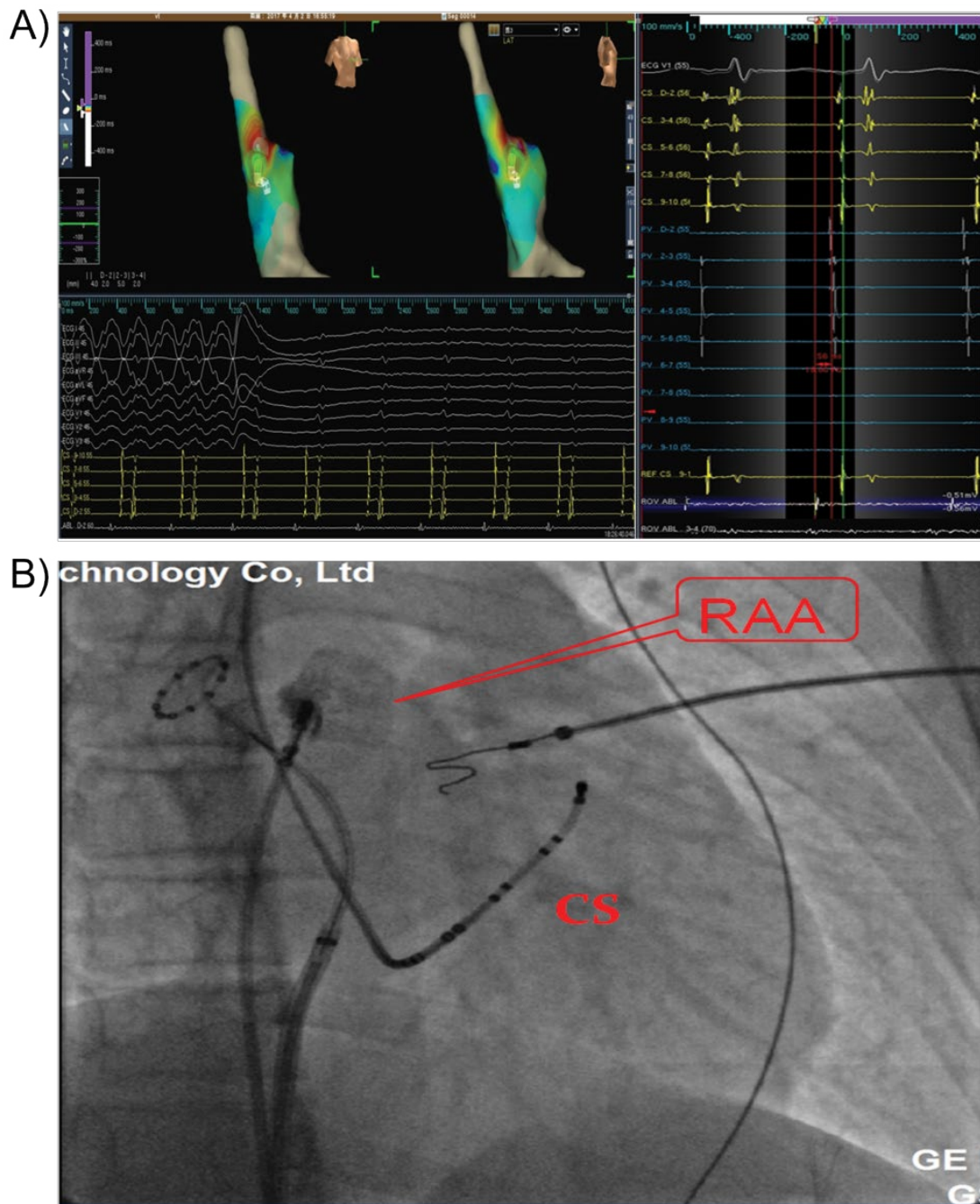


Figure 5. (A) Right atrium from activation mapping (EnSite-NavX) in RAO and LAO view. Activation at the apex of the RAA is the earliest—the A wave of the bipolar electrogram was ahead of the body surface wave 56 ms and **(B)** Right atrial appendage angiography by irrigated catheter (RAO), which occupies a smaller proportion of the right atrium.

Holter monitor recording did not show any tachyarrhythmia despite strenuous exercise.

Discussion

Previous studies show that RAAT occurred in 3.8% of patients with focal AT [6]. However, atrial appendage sites are associated with a high incidence of incessant tachycardia (84%) and LV dysfunction (42%). Patients in the TCM group were younger (mean age 39 ± 22 years vs. 51 ± 17 years, $p=0.0006$) and more frequently male (60% vs. 38%, $p<0.001$). Patients with TCM had a longer mean tachycardia cycle length (502 ± 131 ms vs. 402 ± 105 ms, $p<0.0001$) and slower ventricular rate (117 ± 21 beats/min vs. 141 ± 33 beats/min, $p=0.0007$) during tachycardia compared with patients. Who did not have TCM? After successful ablation, LV function was restored in 97% of patients at a mean of 3 months (2). In our study, two of them were young

and all patients had experienced incessant tachycardia initially, consistent with previous studies' results. As tachycardia progresses, they inevitably cause a deterioration in heart function.

Previous research showed that first-line medications, β -blockers were the most common (53%) and effective (42%) during focal AT, who were followed for a median of 2.1 (95% confidence interval, 1.8–2.6) years, nevertheless, catheter ablation was successful in 80% of patients. Focal AT recurrence was less familiar with electro anatomic mapping than conventional mapping techniques (16% vs. 35%; $P=0.02$) [7]. Because the incessant tachycardia had led to TCM and metoprolol was no effective in our study, mainly, we express our regret that the pregnant woman (Case 1) was forced to terminate her pregnancy in the obstetrics department owing to tachycardia and hypotension before she went to the cardiology clinic for the first time. Therefore, we finally recommended radiofrequency ablation to terminate her tachycardia, fortunately, radiofrequency ablation successfully terminated the RAAT.

Previous research found that focal AT originating during pregnancy may be RAAT, under the guidance of 3-dimension activation mapping, no fluoroscopic RFA with the irrigated-tip catheter is a safe and effective strategy for treating focal RAAT during pregnancy [8].

Considering failure and recurrence after RFCA for RAAT, alternative tools (cryoballoon) may be required in rare instances. A previous case of RAAT that was not terminated by RF ablation, instead, has been successfully ablated using cryoballoon [9,10]. Another treatment suggested that RFCA combination of minimally invasive atrial appendectomy for RAAT [11]. However, cryoballoon might also be an alternative to epicardial ablation or surgery when refractory atrial tachycardia originates from the right atrial appendage [12]. Children not successfully controlled by RFCA or with a recurrence after RFCA could benefit from atrial appendage resection.

In our study, the patients developed tachycardia and TCM even with associated with palpitations dyspnea and during RFCA, Atrial activation mapping revealed that the earliest site of the RAA was diagnosed as inappropriate sinus tachycardia (Case 2 and Case1). TTE and blood system examination during hospitalization can exclude the cause of tachycardia from structural heart disease and other metabolic diseases. In our study, the 24-hour Holter recorded an endless episode of tachycardia, in case 3, atrial tachycardia could not be terminated by transesophageal pacing. Our ablation target was in the RAA, which is near the sinoatrial node. Moreover, we observed RAA in this juvenile was smaller than adult; this may explain why the lead V1 in case 3 (teenagers) was positive, while adults may present negative V1. On the other hand, we considered that juveniles have a shorter history than adults. Therefore, the P wave pattern may be positive in lead V1 and the inferior lead was positive and towering. However, most study reveals that The P wave pattern was negative in lead V1, even in lead V2 and the inferior lead was positive and towering, suggesting the origin of the RAA (Case 2 and Case 1). There have been previous reports of TCM, which has led us to consider the prognosis of RAAT. The presence of atrial tachycardia deriving from RAA may be misdiagnosed as inappropriate sinus tachycardia. Since the RFCA of RAAT was also radically treated. It is also hypothesized that patients with RAAT will develop cardiac insufficiency without treatment. For treating RAAT, the following aspects should be considered. First, avoid triggers (e.g., anemia, infection, pregnancy) and treat for primary diseases. Then, the most commonly used medications were antiarrhythmic drugs, but the effectiveness of the antiarrhythmic drug was not satisfactory. In the last few years, RFCA has become an efficient strategy for treating RAAT. Radiofrequency ablation is a good choice for patients with heart enlargement, poor drug response and strong RFCA willingness.

Conclusions

Although it is difficult to illustrate causality in three cases report, the conclusion can be reached that RAAT may be misdiagnosed as sinus tachycardia easily and induce cardiac insufficiency. Long-term restoration of LV function can be achieved after successful catheter ablation of the tachycardia focus.

Conflict of Interest

None declared.

Consent

Informed consent was obtained from patients for publication of three cases history and associated images.

Ethical Approval

The risk of ablation was discussed in detail. The patient gave written informed consent before radiofrequency ablation. The case report was approved by the ethics committee of Gansu Provincial Hospital (2022-289).

Funding

This study was supported by the Gansu Provincial Sci & Tech. Department (No: 145RJZ104).

Author Contributions

Concept-Yan Huang, Wanpeng Li; Design- Yan Huang, Wanpeng Li, Lijun Zhao; Supervision- Yan Huang; Xuming Ma, Lijun Zhao; Materials-Xuming Ma, Md. Shariful Islam, Jing Yu, Lijun Zhao, Yan Huang; Funding-Yan Huang; Data Collection and/or Processing – Wanpeng Li;Yan Huang; Analysis and/or Interpretation – Wanpeng Li;Yan Huang, Md. Shariful Islam, Lijun Zhao, Jihong Wu; Literature Review –Wanpeng Li; Md. Shariful Islam; Writing –Wanpeng Li, Md. Shariful Islam; Critical Review – Wanpeng Li; Xuming Ma, Md. Shariful Islam, Lijun Zhao, Yan Huang, Jihong Wu

Disclosure

All authors confirmed the contribution of the manuscript and approved the final version.

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How to cite this article: Li, Wanpeng, Md. Shariful Islam, Xuming Ma and Jihong Wu, et al. "Catheter Ablation Effects on Focal Atrial Tachycardia Mistaken for Sinus Tachycardia: A Report of Three Cases." *Clin Med Case Rep* 7 (2023): 251.