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## Rapid firing

## Histological examination of the right atrial appendage after failed catheter ablation for focal atrial tachycardia complicated by cardiogenic shock in a post-partum patient

Akira Mizukami, MD<sup>a,\*</sup>, Makoto Suzuki, MD<sup>a</sup>, Rena Nakamura, MD<sup>b</sup>, Shunsuke Kuroda, MD<sup>a</sup>, Maki Ono, MD<sup>a</sup>, Yuya Matsue, MD<sup>a</sup>, Ryota Iwatsuka, MD<sup>a</sup>, Taishi Yonetsu, MD<sup>a</sup>, Akihiko Matsumura, MD<sup>a</sup>, Yuji Hashimoto, MD<sup>a</sup><sup>a</sup> Department of Cardiology, Kameda Medical Center, 929 Higashi-cho, Kamogawa, Chiba 296-8602, Japan<sup>b</sup> Department of Cardiology, Yokohama Minami Kyousai Hospital, 1-21-1 Mitsuurahigashi, Kanazawa-ku, Yokohama, Kanagawa 236-0037, Japan

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## ABSTRACT

A 26-year-old woman in her first pregnancy presented with persistent atrial tachycardia (AT). AT was resistant to medications, cardioversions, and the first attempt of catheter ablation. Two months after delivery she developed severe systolic dysfunction and circulatory collapse. Emergent catheter ablation was performed with the support of percutaneous cardiopulmonary bypass and intraaortic balloon pump. The AT originated in the apex of the right atrial appendage (RAA). Repeated attempts at ablation were unsuccessful, prompting surgical RAA resection, which terminated the tachycardia and improved the cardiac function. Histological examination of resected RAA provided insights into mechanism of resistance to catheter ablation.

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## 1. Introduction

Atrial tachycardia (AT) resulting in cardiogenic shock requiring circulatory support is a rare entity. AT originating from the right atrial appendage (RAA) is uncommon and may be refractory to radiofrequency catheter ablation.

## 2. Case report

A 26-year-old woman in the 19th week of her first pregnancy presented with a chief complaint of palpitations. Electrocardiogram (ECG) showed sustained AT with heart rate (HR) of 180 bpm. The P wave morphology was positive in the inferior leads, and exhibited a negative to positive transition in leads V1 to V6. Transthoracic echocardiography revealed a structurally normal heart with global mild hypokinesis; the left ventricular ejection fraction (LVEF) was 50%. The AT was resistant to beta-blockers, verapamil, and cardioversions. Because the patient felt exertional dyspnea, we performed radiation-free catheter ablation at the

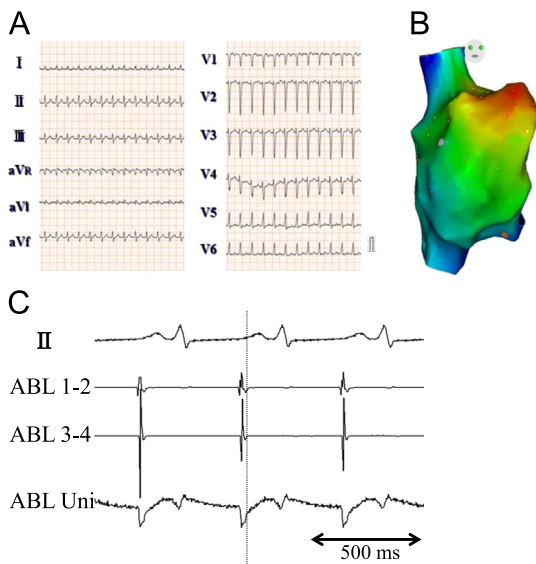
26th week of pregnancy. Using the Electroanatomical mapping system (CARTO), the origin of AT was identified in the apex of the RAA where the local electrogram preceded the P wave onset by 32 ms. Repeated ablation around the focus with both 4 mm tip and irrigated tip ablation catheters (Navi-Star and Navi-Star thermocool, Biosense Webster, CA, USA) prolonged the AT cycle length, but failed to terminate the tachycardia. After the ablation, the patient remained hemodynamically stable despite AT with HR of 140–150 bpm. She continued her pregnancy and delivered a healthy baby at 39 weeks of pregnancy.

AT persisted after delivery. Two months after delivery, the patient developed congestive heart failure. Her ECG showed AT with HR of 200 bpm (Fig. 1A). Brain natriuretic peptide (BNP) was markedly elevated at 1839 pg/mL, and chest X-rays showed cardiomegaly (cardiothoracic ratio=64%) with pulmonary congestion. Transthoracic echocardiography showed severe systolic dysfunction with LVEF of 22%. Amiodarone and landiolol were carefully administered; however, the patient experienced circulatory collapse unresponsive to catecholamines. With her circulation supported by percutaneous cardiopulmonary bypass (PCPB) and intraaortic balloon pump (IABP), we attempted emergent repeat catheter ablation.

The origin of AT was still the apex of RAA (Fig. 1B). The local electrogram at the earliest site of activation preceded the P wave

\* Corresponding author. Tel.: +81 470 92 2211; fax: +81 470 99 1198.

E-mail address: [akmizukami@gmail.com](mailto:akmizukami@gmail.com) (A. Mizukami).

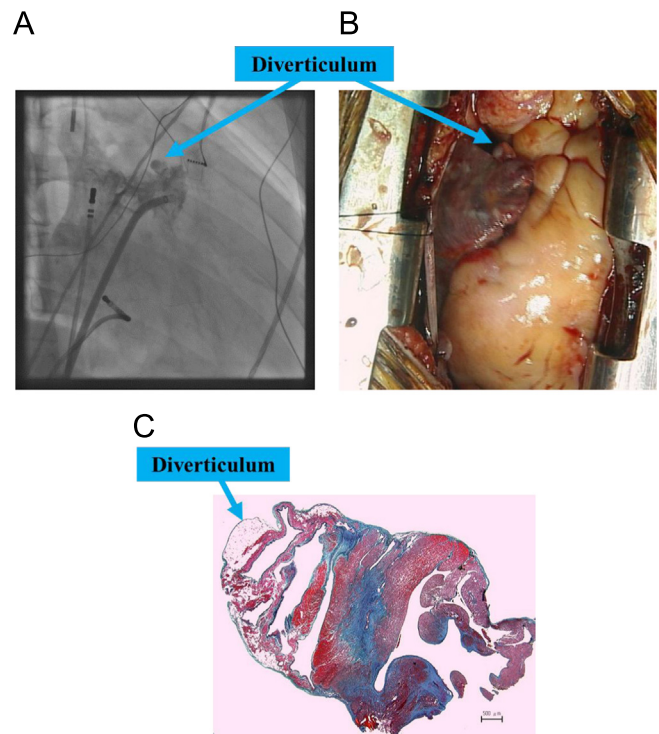


**Fig. 1.** (A) 12-lead ECG of AT with HR of 200 bpm. P wave morphology positive in II, III, aVF, negative to positive transition from V1 to V6. (B). Activation map of RA during AT (RAO 30). The site of earliest activation is at the superior aspect of the apex of RAA. (C) Local electrogram at the site of earliest atrial activation. The electrogram preceded the P wave onset by 34 ms with QS pattern in unipolar electrogram.

onset by 34 ms and had a QS pattern in the unipolar electrogram (Fig. 1C). Multiple RF applications with an 8 mm-tip catheter (Ablase, Life line, Japan) with a power of 30–40 W and target temperature of 55 °C, and an open irrigation catheter (Navi-Star thermocool, Biosense Webster, CA, USA) with a power of 25–40 W and target temperature of 43 °C transiently accelerated the tachycardia without termination. Contrast injection to the RAA revealed a diverticulum around the site of earliest activation at the apex of RAA (Fig. 2A). Attempts to isolate the RAA with encircling lesions also failed; emergent surgery was performed with median sternotomy. RAA with diverticulum and intramural hematoma was visualized (Fig. 2B). RAA resection terminated the tachycardia. Pathologic examination of the resected RAA revealed trabeculation of the pectinate muscles with heterogeneous fibrous scar formation from the first ablation (Fig. 2C). Transmural lesions were rare, and the tip of the diverticulum was intact, explaining the difficulty of RF delivery in the RAA and failure of endocardial ablation. With termination of AT her circulation stabilized, allowing withdrawal of PCPB and IABP as her cardiac function gradually normalized. Plasma BNP value decreased to <2 pg/mL and LVEF on transthoracic echocardiography improved to 67% at 3 months. The patient remained free of AT and heart failure thereafter. A subsequent pregnancy 2 years after treatment was uncomplicated.

### 3. Discussion

Atrial tachycardia originating from the RAA is relatively rare with reported incidence of 3.8–8% of all focal ATs [1,2]. An incessant form of tachycardia that may lead to tachycardia-induced cardiomyopathy is common. Trabeculation of the pectinate muscles and low blood flow within the RAA can cause the temperature and impedance of the ablation catheters to rise, which may prevent effective formation of ablation lesions. Irrigated tip ablation catheters are reportedly more effective than non-irrigated tip ablation catheters. However, especially when the focus of AT is located at the apex or the diverticulum of the RAA, surgery or RAA isolation with Cryoballoon is sometimes necessary [3,4]. In the present case, AT was refractory to ablation even using irrigated tip



**Fig. 2.** (A) Contrast injection to the RAA. Diverticulum is observed at the superior aspect of the RAA apex, around the site of earliest activation. (B) Intra-operative findings. RAA is visualized with median sternotomy. Diverticulum at the superior aspect of the RAA apex and intramural hematoma are observed. (C) Pathological findings of resected RAA with diverticulum. Elastica Masson-Goldner stain of diverticulum of RAA. Heterogeneous fibrosis and scarring (stained in blue) are observed, but transmural lesion is rare. The tip of the diverticulum is intact. The fibrosis and scarring are mostly due to RF application at the first session, since the RAA was resected immediately after the second session without time for fibrous scar formation.

catheters, and surgical resection of RAA was needed to terminate the AT. Pathological findings of the resected RAA clearly explained the difficulty of delivering RF energy to the apex and the diverticulum of the RAA.

Pregnancy may induce arrhythmias due to myocardial stretch from increased blood volume, increased sympathetic tone due to increased sensitivity of adrenergic receptors, and the effect of hormones such as estrogen and progesterone [5]. In most cases of pregnancy-induced arrhythmia, the arrhythmia subsides after delivery. However, arrhythmias may become sustained or recurrent.

The main cause of decreased cardiac function in this case was thought to be tachycardia-induced cardiomyopathy considering the full recovery of cardiac function with termination of AT and her uncomplicated subsequent pregnancy. However, requirement of circulatory support with tachycardia-induced cardiomyopathy is rare; pathophysiology similar to that of peripartum cardiomyopathy may have coexisted and affected the clinical course. Close follow-up after delivery and early aggressive intervention to the arrhythmia could have prevented the circulatory collapse in this patient.

Recent advances in ablation technologies and techniques such as epicardial ablation and cryoablation may improve the outcome of catheter treatment of ATs originating in the RAA.

### 4. Conclusions

We report a case of failed catheter ablation for focal atrial tachycardia originating from the RAA in a post-partum woman who developed cardiogenic shock requiring circulatory support.

The anatomical features of the RAA likely contributed to our inability to achieve effective ablation. The post-partum state of the patient might have affected her severe clinical course.

#### **Conflict of interest**

All authors declare no conflict of interest related to this study.

#### **Acknowledgments**

None.

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