Rescue percutaneous coronary intervention for sinus node dysfunction following left atrial flutter ablation

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Introduction
Perimital flutter (PMFL) is a common arrhythmia after ablation of atrial fibrillation. In some cases of PMFL, an anterior line is selected instead of the mitral isthmus line owing to technical and anatomical issues.1,2 In such cases, the sinus nodal artery (SNA) courses high on the anterior left atrium (LA) and is close to the block line on the anterior wall of the LA.3 Hence, the SNA could be injured by radiofrequency (RF) ablation leading to sinus node dysfunction (SND).4,5 Percutaneous coronary intervention (PCI) for SND due to SNA occlusion after stent implantation has been reported.6 However, few reports have shown the efficacy of the interventional strategy for SNA injury after RF application.

We report a case of SND following RF application on the anterior wall of the LA that was successfully managed using PCI for the occluded SNA.

Case report
A 66-year-old male patient with a history of 3 catheter ablations for paroxysmal atrial fibrillation was referred to our hospital for recurring atrial tachyarrhythmia; clinical arrhythmia was induced by an overdrive in atrial pacing. During repeat ablation, 3-D electroanatomical mapping revealed that the earliest atrial activation site in sinus rhythm was the junction of the superior vena cava and right atrium. Using a multielectrode catheter (PentaRay; Biosense-Webster, Inc, Diamond Bar, CA), 3-D mapping of the LA revealed that the tachycardia was PMFL. As there was a broad low-voltage area in the anterior wall of the LA during sinus rhythm (Figure 1), linear ablation from the mitral annulus to the right superior pulmonary vein was selected instead of the mitral isthmus line. Using an irrigated tip catheter (ThermoCool SmartTouch SF; Biosense-Webster, Inc), catheter ablation was performed on the anterior wall of the LA between the mitral annulus and right superior pulmonary vein (power, 35 W). However, the PMFL could not be terminated. Mapping of the LA using a multielectrode catheter revealed a gap in the PMFL circuit near the ostium of the LA appendage. As the circuit coursed into intramural LA, additional RF application (power, 40 W) was delivered near the ostium of the LA appendage, and the PMFL terminated to sinus rhythm (Figure 1). A few minutes after the final RF application, sinus rhythm disappeared and junctional rhythm appeared without significant ST changes. Although the sedative agent was stopped and continuous dopamine infusion (5.0 μg/kg per minute) was started for bradycardia and hypotension, sinus rhythm did not return. In view of irregular sinus node function (SNF) even after 2 days, coronary computed tomographic angiography was performed; it revealed occlusion of the SNA (Figure 2).

Conflcit of Interest: The authors have no conflicts to disclose. Funding Sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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KEY TEACHING POINTS

- The sinus nodal artery (SNA) coursing along the high anterior left atrium (LA) can be injured by radiofrequency (RF) application to the LA anterior wall, leading to sinus node dysfunction.
- The intravascular ultrasound images obtained in the present case indicate that RF application may lead to the partial destruction of the vessel wall structure of the SNA, resulting in arterial occlusion.
- Percutaneous coronary intervention for occluded SNA could be a useful strategy to recover sinus node function and avoid permanent pacing.

KEYWORDS Anterior line; Percutaneous coronary intervention; Radiofrequency ablation; Sinus node dysfunction; Sinus nodal artery

(Heart Rhythm Case Reports 2021;7:529–532)
left circumflex artery and remained occluded even after intracoronary nitroglycerin administration (Figure 2). Subsequently, PCI was performed, and a hydrophilic polymer-jacketed 0.014- to 0.010-inch tapered guide wire (XT-R; ASAHI INTECC CO, LTD, Aichi, Japan) was successfully advanced distal to the occluded site of the SNA. Intravascular ultrasound (IVUS) revealed the absence of a 3-layered structure in the vessel wall on the LA side at the occluded site, where the echogenicity of the adventitia was relatively low. After balloon angioplasty using a 1.5 × 10 mm semi-compliant balloon (ZINRAI; Kaneka Corporation, Tokyo, Japan), the SNA was successfully recanalized (Figure 3). SNF recovered immediately after PCI, allowing termination of the dopamine infusion. No bradycardia, sinus pause, or atrial tachyarrhythmia occurred after PCI.

**Discussion**

Acute SND can occur following linear ablation on the anterior wall of the LA, as shown in previous reports; the mechanism was thought to be direct thermal injury to the SNA. However, the precise mechanism underlying the thermal injury remains unclear; IVUS images obtained in this case indicate that RF application may lead to the partial destruction of the SNA vessel wall, resulting in arterial occlusion. The presence or absence of a luminal thrombus could not be determined using IVUS owing to the small size of the SNA, while a relatively low echogenicity of the adventitia on the LA side potentially

![Figure 2](image-url)
indicated degeneration of the adventitial tissue after ablation, with or without interstitial edema.

SNA injury is more likely to result in SND if the SNA is the sole supply to the sinus node. The prevalence of an exclusively left-sided SNA is 30%–40%, and more than half run high on the anterior LA; this could be a risk factor for SND in cases of anterior LA ablation. It is important to determine the anatomy of the SNA and limit energy delivery to avoid SND after RF ablation. Nevertheless, creating an anterior line cannot be achieved without high RF energy in cases with PMFL circuits that involve fibers of the Bachmann bundle, an epicardial structure.

The sinus node is reported to be resistant to anoxia as well as to increases in extracellular potassium; however, the detailed mechanism is not well understood. As a previous study reported that the atrial pacing rate ranged from less than 1% to 99% (approximately half of the cases did not depend on atrial pacing) after pacemaker implantation for SND after ablation for paroxysmal atrial fibrillation, SNF appears to be reversible. The collateral vessels supplying blood to the sinus nodal cells could be one of the causes. Since SNF is reversible, SND after catheter ablation may resolve spontaneously within a few days. However, previous reports have shown that SND frequently fails to recover completely after catheter ablation and requires permanent pacing. That may be because the SNA of patients in those reports was not recanalized. The current case, for the first time, demonstrates the successful recovery of a postablation SND using PCI for the occluded SNA. Recanalization of the SNA was effective 2 days after catheter ablation. Our case shows that PCI can help recovery from SND and avoid permanent pacing, especially in cases requiring high RF for ablation on the anterior wall of the LA.

**Conclusion**

The current case showed that SND during the ablation procedure, especially at the anterior wall of the LA, can cause SNA injury; PCI for the occluded SNA can be a useful strategy to recover SNF and avoid permanent pacing.
Acknowledgments
Written informed consent was obtained from the patient. The authors thank Editage (www.editage.com) for English-language editing.

References
1. Chiang SJ, Tsao HM, Wu MH, et al. Anatomic characteristics of the left atrial isthmus in patients with atrial fibrillation: lessons from computed tomographic images. J Cardiovasc Electrophysiol 2006;17:1274–1278.
2. Becker AE. Left atrial isthmus: anatomic aspects relevant for linear catheter ablation procedures in humans. J Cardiovasc Electrophysiol 2004;15:809–812.
3. Yokokawa M, Sundaram B, Oral H, Morady F, Chugh A. The course of the sinus node artery and its impact on achieving linear block at the left atrial roof in patients with persistent atrial fibrillation. Heart Rhythm 2012;9:1395–1402.
4. Hai JJ, Mulpuru SK, Williamson EE, Foley TA, Brady PA. Sinus nodal dysfunction after left atrial flutter ablation: a preventable complication. Circ Arrhythm Electrophysiol 2014;7:360–361.
5. Barra S, Gopalan D, Baran J, Fynn S, Heck P, Agarwal S. Acute and sub-acute sinus node dysfunction following pulmonary vein isolation: a case series. Eur Heart J Case Rep 2018;2:1–6.
6. Haraki T, Hirase H, Hoda S, Hashimoto M, Higashi M. Sinus dysfunction after stent implantation in the right coronary artery immediately recovered after reflow in the sinus node artery. Cardiovasc Interv Ther 2014;29:173–176.
7. Choi EK, Lee W, Oh S. Reversible sinus node dysfunction after multiple ablations along the course of the sinus nodal artery in patient with paroxysmal atrial fibrillation. Europace 2013;15:1388.
8. Chugh A, Makkar A, Ho SY, et al. Manifestations of coronary arterial injury during catheter ablation of atrial fibrillation and related arrhythmias. Heart Rhythm 2013;10:1638–1645.
9. Mangrum JM, DiMarco JP. The evaluation and management of bradycardia. N Engl J Med 2000;342:703–709.
10. Loeb JM, Euler DE, Randall WC, Moran JF, Brynjolfsson G. Cardiac arrhythmias after chronic embolization of the sinus node artery: alterations in parasympathetic pacemaker control. Circulation 1980;61:192–198.
11. Abe Y, Tamura A, Kadota J. Prolonged sinus node dysfunction caused by obstruction of the sinus node artery occurring during coronary stenting. J Electrocardiol 2008;41:656–658.