Sinus node dysfunction caused by a sinus node artery occlusion during catheter ablation and sinus rhythm restoration post-PCI

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Introduction

In recent years, catheter ablation has emerged as the cornerstone strategy for treating atrial fibrillation (AF).[1,2] Although several complications of catheter ablation have been reported,[3] clinically manifest coronary artery injury during catheter ablation of AF remains rare (0.14%).[4] However, the occurrence of coronary artery injury is reported to be even rarer than coronary artery spasms. In cases with an acute coronary artery occlusion, nitroglycerin can be injected into the coronary artery to alleviate the coronary artery spasms, but if this does not improve, percutaneous coronary intervention (PCI) becomes necessary. Unexpected sinus arrest induced by radiofrequency (RF) ablation without direct injury to the sinus node is a rare complication of AF ablation and may be associated with acute sinus node dysfunction (SND). The prevalence of sinus node artery (SNA) injury is reported to be 0.09%, with its mechanism linked to the location of the SNA.[4] Moreover, injury to the SNA may lead to prolonged SND, resulting in the need for a permanent pacemaker. The use of low-power settings for the RF ablation is important to minimize the risk of arterial injury. Unexpected anatomical abnormalities of the SNA are also considered a predisposing factor for coronary artery injury during catheter ablation procedures.[4,5] We present 2 cases of occluded SNAs during left pulmonary vein isolation and RF ablation of the mitral isthmus, resulting in SND that was reversed after PCI. Informed consent was obtained in accordance with Prefectural Saiseikai Izuo Hospital regulations.

Case 1

A 77-year-old man with paroxysmal AF underwent cryoballoon ablation. Because of hypertension and age, his congestive heart failure, hypertension, age, diabetes mellitus, prior stroke or transient ischemic attack or thromboembolism, vascular disease, age, sex category (CHA2DS2-VASc) score was 3. He received cryoballoon ablation of the left and right pulmonary veins and left atrial roof. We did not find any SND on the electrocardiogram (ECG) after the first session of cryoballoon ablation for AF. Two months later, he experienced recurrent palpitations and was admitted to our hospital. His ECG showed atrial tachycardia (AT). Despite severe palpitations, his arrhythmia improved to sinus rhythm with the administration of verapamil. The following day, catheter ablation therapy with RF ablation for AT was performed. Antiarrhythmic drugs, including beta-blockers, were discontinued 24 hours before the procedure. The AT was peri-mitral flutter. We created a block line from the left inferior pulmonary vein to the mitral valve (lateral mitral isthmus line) with an irrigated catheter (1 cycle of 30 W for 30 seconds). During the RF application, suddenly he had sinus arrest and an escape rhythm lasting over 30 minutes without ST-T changes. Therefore, we decided to perform coronary angiography (CAG), which revealed an occlusion of the SNA branching from the circumflex artery that was not observed before the ablation procedure (Figure 1A and 1B). We performed PCI because the occlusion did not improve even after injecting enough nitrate preparation into the coronary artery. We successfully passed the guidewire smoothly through the

KEY TEACHING POINTS

- Preoperative coronary angiography or contrast-enhanced CT may be useful as a reference to estimate the course of SNA.
- Coronary angiography/ intervention should be considered within 30 minutes of significant bradycardia or rhythm changes.
- If the SNA is occluded and the SND persists during the ablation procedure, PCI should be considered as a treatment option.

KEYWORDS Sinus node artery occlusion; Sinus node dysfunction; Pulmonary vein isolation; Percutaneous coronary intervention; Catheter ablation

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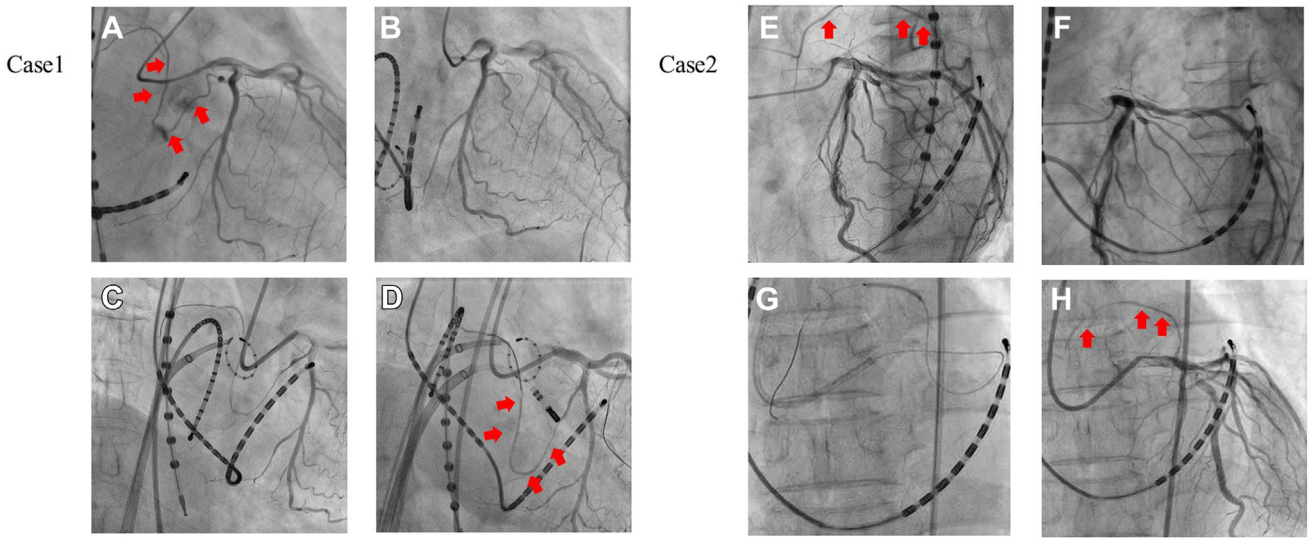

Figure 1 Coronary angiography and percutaneous coronary intervention. Coronary angiography (CAG) was performed before the ablation procedure (Figure 1A in case 1 and Figure 1E in case 2), showing the sinus node artery (SNA) branching from the circumflex artery (*red arrow*). During ablation, CAG revealed an occlusion of the SNA (Figure 1B in case 1 and Figure 1F in case 2). A guidewire was passed through the occluded SNA, and percutaneous coronary intervention (PCI) was performed on the SNA (Figure 1C in case 1 and Figure 1G in case 2). Post-PCI contrast revealed an improved blood flow in the SNA (*red arrow*) (Figure 1D in case 1 and Figure 1H in case 2).

lesion and performed percutaneous old balloon angioplasty (POBA) (Ryurei diameter, 1.5 mm × length 10 mm, manufactured by Terumo, Tokyo, Japan) (Figure 1C). As a result, the ischemia of the SNA was relieved (Figure 1D). Because bradycardia was expected to persist for some time, a temporary pacemaker was placed, and nitrate preparations and dopamine were continuously injected intravenously. After completing the catheterization, the patient's condition was monitored. The bradycardia recovered by the next day (Figure 2D), so the dopamine, nitrates, and temporary pacemaker were discontinued. Thereafter, no further bradycardia or AT recurred, and his palpitations resolved.

Case 2

A 68-year-old man underwent extensive encircling pulmonary vein isolation for persistent AF. Because of age, chronic heart failure, and hypertension, his CHA2DS2-VASc score was 3. We did not find any SND on the ECG after the first session of catheter ablation for AF. Two months later, his AF recurred, prompting a re-do procedure. Antiarrhythmic drugs, including beta-blockers, were discontinued 24 hours before the procedure. We attempted to create a roofline from right pulmonary vein to the left pulmonary vein. During the ablation of the anterior wall of the left pulmonary vein (8 cycles, 30 W × 30 seconds), a sinus bradycardia suddenly appeared without ST segment abnormalities on the ECG. We immediately stopped the RF application, but the sinus bradycardia persisted (Figure 3C), so we performed CAG. The CAG revealed an occlusion of the SNA that was not observed before the ablation procedure (Figure 1E and 1F). After completing the ablation procedure, the sinus bradycardia persisted for more than 1 hour in total, and sufficient nitrates added into the coronary artery did not improve the obstruction. We decided to perform PCI on the occluded segment of the SNA. After successfully passing a guidewire through the lesion and performing POBA (Ryurei diameter, 1.5 mm × length 10 mm, manufactured by Terumo) (Figure 1G), nitrates and heparin were injected into the coronary artery, and the procedure was completed without contrast delay and with a good coronary flow (Figure 1H). His ECG promptly improved to sinus rhythm (Figure 3D). The continuous infusion of the nitrates and heparin was discontinued until the next day. Thereafter, he did not experience any recurrence of SND or AF.

Discussion

To our knowledge, this is the first report of sudden SND during a left pulmonary vein or mitral annulus ablation followed by PCI to correct the dysfunction after an SNA obstruction was confirmed. Several points are worth discussing. In both cases, SND occurred during the ablation of the left pulmonary vein and mitral annulus rather than the right pulmonary veins or septal superior vena cava–right atrium junction. The CAG showed the SNA occlusion, with the SNA branching from the circumflex artery. Variations in the SNA branching have been reported, with Vikse et al[6] noting that 68.0% of SNAs branch from the right coronary artery and 22.1% from the left circumflex artery.[6] Angiography in our cases showed that the SNA bifurcation originated from the middle part of the circumflex branch. SND can occur during ablation of the left pulmonary vein and peri-mitral isthmus, because the SNA may branch from the left circumflex branch, as seen in our cases. Although SND during ablation procedures has been reported previously, CAG is not usually performed if it occurs during RF ablation, and a temporary pacemaker is often used until the dysfunction improves. There have been

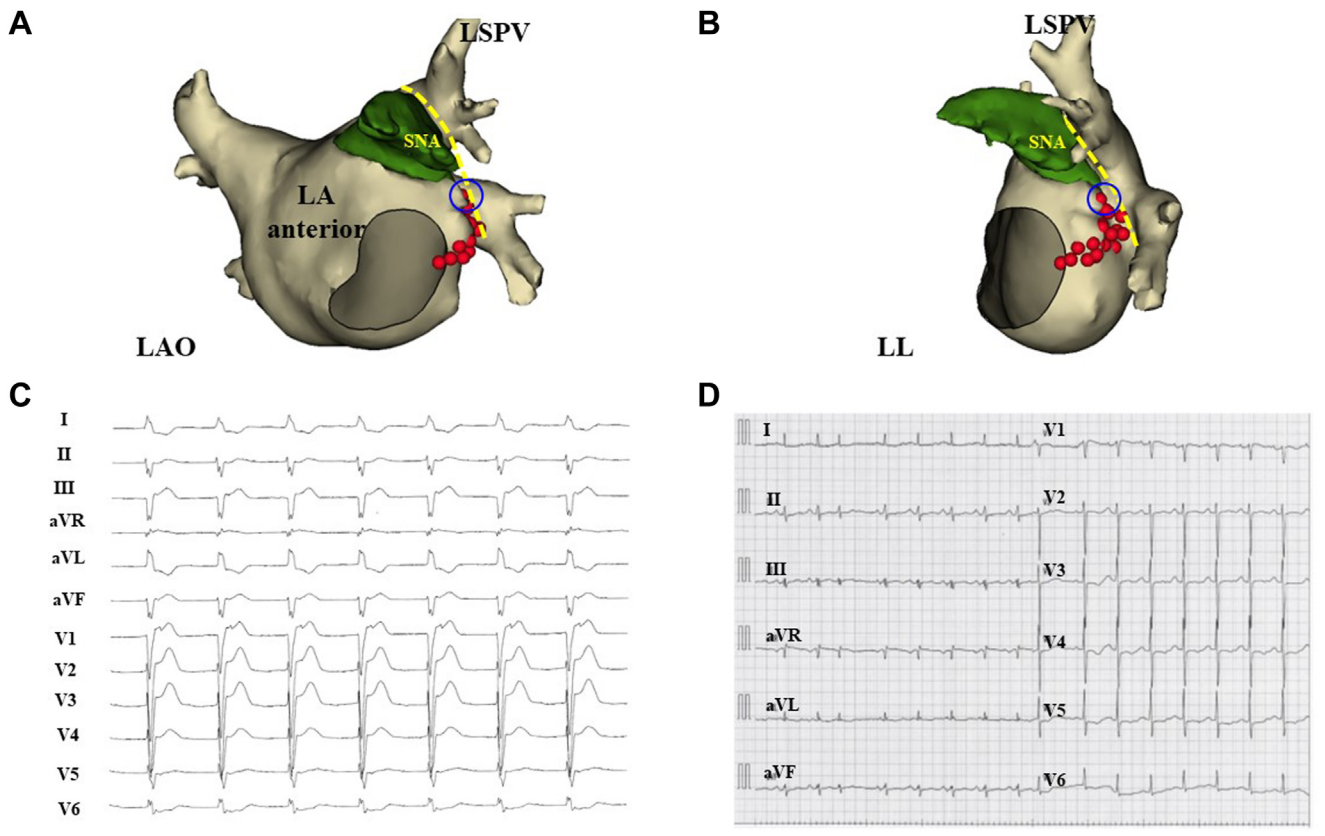

Figure 2 Location of the radiofrequency ablation and electrocardiographic changes in case 1. The points in the left atrium where radiofrequency ablation (RF) was performed are shown with *red-filled circles* in Figures 2A and B. Figure 2A shows the LAO view, and Figure 2B shows the LL view. A sinus arrest and escaped rhythm on the ECG shown in Figure 2C appeared when RF was performed on the area indicated by the *unfilled blue circle* in Figures 2A and 2B. The ECG improved to sinus rhythm with premature atrial contraction by the next day (Figure 2D). The *green area* indicates the left atrial appendage (Figures 2A and 2B). The *yellow dotted line* indicates the location of the sinus node artery inferred from coronary angiography (Figures 2A and 2B). ECG = electrocardiogram; LA = left atrial; LL = left lateral; LSPV = left superior pulmonary vein; SNA = sinus node artery.

no reports of an occlusion of the SNA resulting in SND during ablation therapy and a PCI of the SNA. We administered enough nitrates to the coronary artery, but the occluded SNA did not improve, suggesting negative coronary spasms. Therefore, we performed a PCI. Because of the small vessel diameter of the SNA (1.5 mm), we performed POBA without stenting. After revascularization of SNA, SND improved by the next day in case 1 and immediately after performing PCI in case 2, and in both cases heart failure was not apparent and permanent pacemaker implantation was avoided. Baskovski et al[7] reported that nitroglycerin administration improved obstructive SNA,[7] suggesting a possible involvement of coronary spasm. Conversely, Funayama et al[8] used optical frequency domain imaging to evaluate the acute vascular response after ablation and reported vessel wall thickening and thrombus formation at the lesion site without evidence of spasm and plaque rupture, suggesting that the coronary artery occlusion was attributable to thermal trauma caused by the RF application, resulting in wall thickening from edema and ultimately leading to thrombosis.[8] In our cases, despite the administration of sufficient nitrate preparation, the flow of the SNA did not improve and the SND persisted for more than 30 minutes. This suggests that the cause of the obstruction was not spasm but coronary artery edema and subsequent thrombus formation. The sinus node may receive dual blood supply and SND may improve without POBA, but sinus node recovery may take longer.[7] Chugh et al[4] reported the incidence of coronary artery injury and clinical outcomes in a large series of patients undergoing catheter ablation for AF and AT, in which 5 of 5709 patients developed SND and 2 required permanent pacemaker implantation. One of our patients had a history of heart failure and was at risk of worsening heart failure with prolonged SND, and right ventricular pacing in the presence of cardiac dysfunction also may be a predictor of worsening heart failure. We recommend a preoperative assessment of the coronary arteries and careful attention paid to the course of the SNA before proceeding with the ablation procedure. The CAG before ablation can clearly identify the location of the SNA, but it is not commonly performed, whereas contrast-enhanced CT is routinely performed. If the contrast-enhanced CT confirms the location of the SNA, the planned ablation line may be modified, or the thermal ablation force may be reduced to avoid damage to the SNA and associated SND. Based on our experience, CAG/PCI should be considered within 30 minutes from the onset of significant bradycardia or rhythm

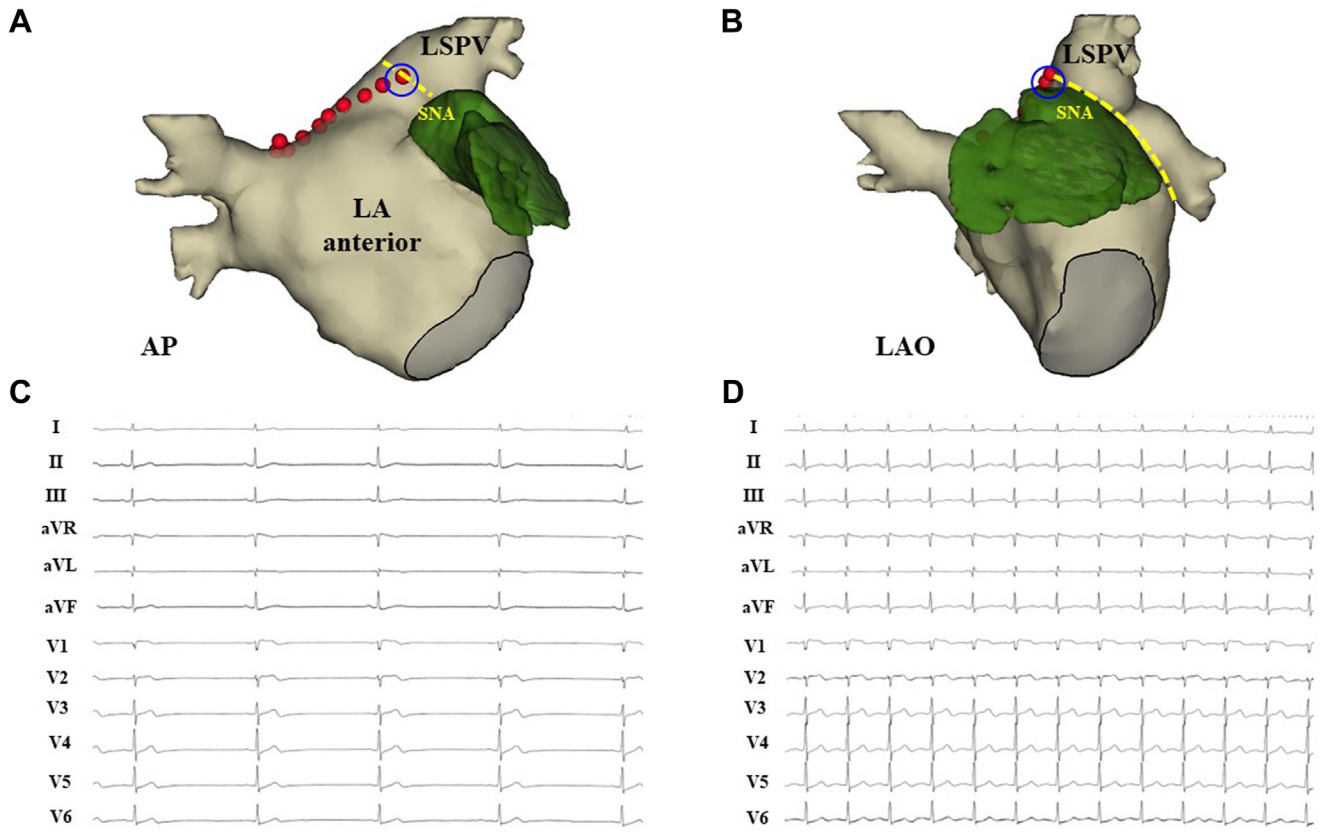

Figure 3 Location of the radiofrequency ablation and electrocardiographic changes in case 2. The points in the left atrium where radiofrequency ablation (RF) was performed are shown with *red-filled circles* in Figures 3A and 3B. **A:** AP view. **B:** LAO view. **C:** A sinus bradycardia on the ECG occurred when RF was performed on the area indicated by the *unfilled blue circle* in Figures 3A and 3B. **D:** Subsequently, the ECG improved to sinus rhythm after the percutaneous coronary intervention. The *yellow dotted line* indicates the location of the sinus node artery inferred from coronary angiography (Figures 3A and 3B). AP = anterior posterior; ECG = electrocardiogram; LA = left atrial; LAO = left anterior oblique; LSPV = left superior pulmonary vein; SNA = sinus node artery.

changes. Rapid intervention is crucial to relieve ischemia and reduce the risk of prolonged SND. The decision to perform PCI, even for small vessel diameters, should be based on the patient's background and hemodynamics.

Conclusion

We present 2 cases of SND during catheter ablation, confirmed by an SNA occlusion that was improved by PCI. If the SNA arises from the middle of the circumflex artery, its route should be confirmed preoperatively, because ablation of the anterior wall of the left pulmonary vein or the left atrial roof and mitral annulus may occlude the SNA. If SND occurs during catheter ablation, CAG should be performed to confirm the SNA flow. PCI also should be considered as a treatment option if an obstruction is confirmed.

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