An iatrogenic peri–left atrial appendage reentry after cryoisolation of a postsurgery left atrial appendage stump

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Introduction
The left atrial appendage (LAA) has been known as a source of focal atrial tachycardias (AT). Radiofrequency (RF) energy–based focal ablation of these arrhythmias is a common strategy for most cases. However, some cases could be challenging owing to the complexity of the LAA anatomy. Sometimes an epicardial approach is an alternative when endocardial ablation fails. Cryoballoon (CB)-based LAA isolation could be considered before epicardial access. We report a patient with focal AT that originated in the tip of an LAA surgery ligation stump. The patient underwent a heart valve mitral bioprosthesis replacement and had the LAA ligated during the operation 10 years ago. After the focal RF ablation failed, we performed an LAA stump electrical isolation using a CB and successfully terminated the tachycardia. The patient was put on oral anticoagulation for concerns of thromboembolism. Two years later, the patient was readmitted for continuous atrial flutter. Activation mapping revealed an iatrogenic channel between the mitral annulus and the isolated LAA stump, which was formed by the last LAA stump cryoablation. Linear ablation at this channel successfully terminated the atrial flutter.

Case report
The patient was a 70-year-old man who presented with drug-refractory AT. He had undergone bioprosthetic mitral valve replacement, tricuspid valvuloplasty, and LAA ligation 10 years before. His 12-lead electrocardiography demonstrated AT (Figure 1A). The tachycardia perimeter is not constant and varies greatly; cycle length (CL) of the tachycardia varied between 298 and 325 ms (Supplemental Figure 1), so the value of entrainment is limited. Ultra-high-density mapping (Rhythmia™; Boston Scientific, Marlborough, MA) of the left atrium (LA) revealed it to be a focal left AT, with the earliest activation site inside the tip of the LAA stump (Figure 1B and 1C). We then performed LAA angiography, which revealed a major LAA stump 10 mm wide (Figure 1D). Before cryoablation, we paced around the LAA stump to make sure the RF lesions were made in an irrigated mode (rate, 17 mL/min) with power of 10–15 W and temperature of –40°C. The AT recurred 2 days later. Surgical resection of the LAA was proposed. The patient and his family refused surgery resection and chose interventional catheter ablation.

The patient was put on a second operation. Activation mapping showed that the tachycardia was from the same origin (Figure 2A). We then attempted to electrically isolate the LAA stump using a second-generation 28 mm CB (CB2; Arctic Front Advance; Medtronic, Minneapolis, MN), the CB was inflated and the complete LAA occlusion was confirmed using angiography (Figure 2B). Before cryoablation, we paced around the LAA stump to make sure the

KEY TEACHING POINTS
- Focal atrial tachycardia (AT) from a ligated left atrial appendage (LAA) stump is very rare.
- Cryoballoon (CB) electrical isolation could be safe and effective in treating focal AT originating in the tip of the LAA stump.
- Iatrogenic atrial flutter could be caused by the channel between the mitral annulus and the isolated LAA formed by the CB ablation.

KEYWORDS
Atrial tachycardia; Left atrial appendage stump; Residential flow; Cryoablation; Anticoagulation; Rhythmia system; Iatrogenic arrhythmia; Atrial flutter; High-density mapping; Carto system

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phrenic nerve was not stimulated. During the cryoablation, AT was terminated (Figure 2C). Cryoablation was performed twice, with each cryoablation time 100 seconds. The minimum temperatures were \(-46^\circ C\) and \(-44^\circ C\), respectively. After the cryoablation, an inner lumen circular mapping catheter (Achieve 15 mm; Medtronic, Minneapolis, MN) was put into the LAA stump. Pacing in the LAA stump at a frequency of 400 ms could not capture the atrium, confirming the electrical isolation of the LAA stump (Figure 2D). For concerns of thromboembolism, the patient was put on a continual oral anticoagulation after the procedure. He remained sinus during the follow-up.

Two years later, the patient was readmitted to the emergency room for palpitations and shortness of breath. His electrocardiogram showed atrial flutter with 2:1 AV conduction (Figure 2E). He again refused surgical operation. During the third ablation, a PentaRay catheter (Biosense Webster, Diamond Bar, CA) was used for high-density mapping. Low-voltage areas could be found at the bottom of the LAA stump (Figure 3B) and electrical isolation of the LAA stump was confirmed. An isthmus was formed between the LAA isolation line and the bioprosthetic mitral annulus.

Activation mapping of the LA showed a short-CL 200 ms reentrant atrial flutter circling the root of the LAA stump in a clockwise pattern (Figure 3C and 3D). Entrainment using an ablation catheter around the reentrant loop were attempted but failed, owing to its short CL and the low-voltage area around the LAA stump. According to the activation mapping, the isthmus between the base of the LAA stump and the mitral annulus was the key channel of the reentrant loop (Supplemental video 1). The RF lesions were made in an irrigated mode (rate, 17 mL/min) of 35 W at 43°C. Linear ablation was performed across the channel from the LAA stump root to the mitral isthmus and the tachycardia was terminated (Figure 3E and 3F). The patient remained symptom free during the follow-up.

Discussion
Owing to its anatomical complexity, LAA-originated AT has long posed challenges for radiofrequency ablation. Further, focal AT from a ligated LAA stump is very rare. The thinness and fragility of the LAA stump increases the risks of cardiac perforation and tamponade. Successful electrical isolations of
both right atrial appendage and LAA with CBs have been previously reported.\textsuperscript{4,5} Cryoablation could be safe and effective in isolating the LAA for these patients. However, LAA electrical isolation might increase the thromboembolic risk\textsuperscript{6}; further, the risk of embolic events increases in patients with incomplete surgical LAA ligation.\textsuperscript{7} This case was at high thromboembolic risk for both incomplete surgical LAA ligation and LAA isolation. We deemed it necessary that the patient take long-term anticoagulants.

Our case for the first time showed that an iatrogenic channel could be formed between the LAA stump and the mitral annulus, which could be a potential substrate for atrial flutter around the electrically isolated LAA stump. Between the LAA and mitral annulus, we did not find any abnormal potentials (Supplemental Figure 2). Still, it could not be ruled out that tissue lesions around the mitral annulus caused by previous mitral valve replacement may be involved in the formation of the LA reentrant loop.

In conclusion, although CB electrical isolation could be safe and effective in treating focal AT originating in the tip of the LAA stump, our case also shows that iatrogenic atrial flutter could be formed depending on the channel between the mitral annulus and the isolated LAA.

**Appendix**

**Supplementary data**

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2022.01.016.
Figure 3  A: Electrocardiogram shows an atrial flutter with 2:1 AV conduction, with a short cycle length of 200 ms. B: The corresponding voltage map of the left atrium. C: Activation map: reentrant tachycardia around the left atrial appendage (LAA) through the channel between the prosthetic mitral valve and the LAA stump. There is an iatrogenic channel made by the cryoballoon that isolated the LAA stump (red double arrows). D: The last LAA cryoballoon ablation angiography image. E: Linear ablation was performed across the channel between the LAA and the mitral isthmus (red ablation points). F: During the linear ablation, tachycardia was terminated and converted to sinus rhythm.
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