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SPOTLIGHT

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Indirect epicardial targeting of left atrial tachycardia using Bachmann's bundle: A case report of successful ablation from pulmonary artery

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Catheter ablation (CA) has emerged as a cornerstone therapeutic modality for managing atrial fibrillation (AF) and atrial tachycardia (AT). Despite advancements in endocardial ablation techniques, a subset of patients exhibiting nonpulmonary vein triggers, occasionally manifesting as ATs with involvement of epicardial tissues, presents formidable challenges to achieve successful rhythm control. In cases where comprehensive endocardial ablation has failed, this situation may necessitate innovative approaches, such as epicardial ablation via subxiphoid puncture, application of radiofrequency (RF) energy from anatomically adjacent areas near the arrhythmogenic source, or intravenous alcohol injection into the vein of Marshall (VOM).

A 59-year-old female patient, previously treated with PV isolation using cryoablation for atrial fibrillation (AF) and subsequent endocardial RF ablation targeting substrate modification (Anterior Mitral Isthmus line ablation and posterior wall isolation) for atrial tachycardias (ATs) after AF ablation at different arrhythmology centers, presented to our clinic because of sustained, highly symptomatic AT episodes beginning one week after her last ablation.

The admission electrocardiogram (ECG) showed left AT (Figure 1). The procedure was performed under moderate sedation provided by midazolam administration, with a total of 15000 units of intravenous unfractionated heparin administered and continuous monitoring of activated clotting time (ACT). To provide the analgesic component during the procedure, a total of 50–100 μg of intravenous fentanyl was used. No electrical cardioversion or administration of antiarrhythmic drugs was conducted during the procedure. The THERMOCOOL SMARTTOUCH® SF Catheter (8Fr-DF curve) was chosen for its suitable features. Left atrium (LA) mapping during AT (tachycardia cycle length (TCL)—363 ms) with an eccentric coronary sinus activation sequence was performed using the CARTO electroanatomic mapping system V7.2. PVs and posterior wall were confirmed to be isolated, with extensive scarring noted on the anterior septum and adjacent roof. High-density multipolar mapping using a Pentaray catheter indicated AT exiting at the anterosuperior mid-septum (Figure 2). Left atrial entrainment maneuvers were not performed because of the risk of terminating tachycardia and the presence of an active local figure-of-eight appearance of AT (Video S1).

Despite a large scar in the anterior superior area just anterior to the right PVs isolation line where no electrograms (EGMs) were detected over the Bachmann's bundle (BB) region, and local activation mapping showed that 35% of the tachycardia cycle length was missing, we suspected an epicardial bridge involving BB. Application of 50 W RF energy to this area transiently slowed and repeatedly terminated the AT (Video S2). However, despite creating an additional lesion set to prevent the septopulmonary bundle from penetrating the posterior atrial endocardium, the same AT later spontaneously reinduced despite extensive and prolonged homogenization (Figure 3D, Video S3 and summary figure).

Before attempting a classical subxiphoid puncture for a direct epicardial approach, we opted to first map the pulmonary artery

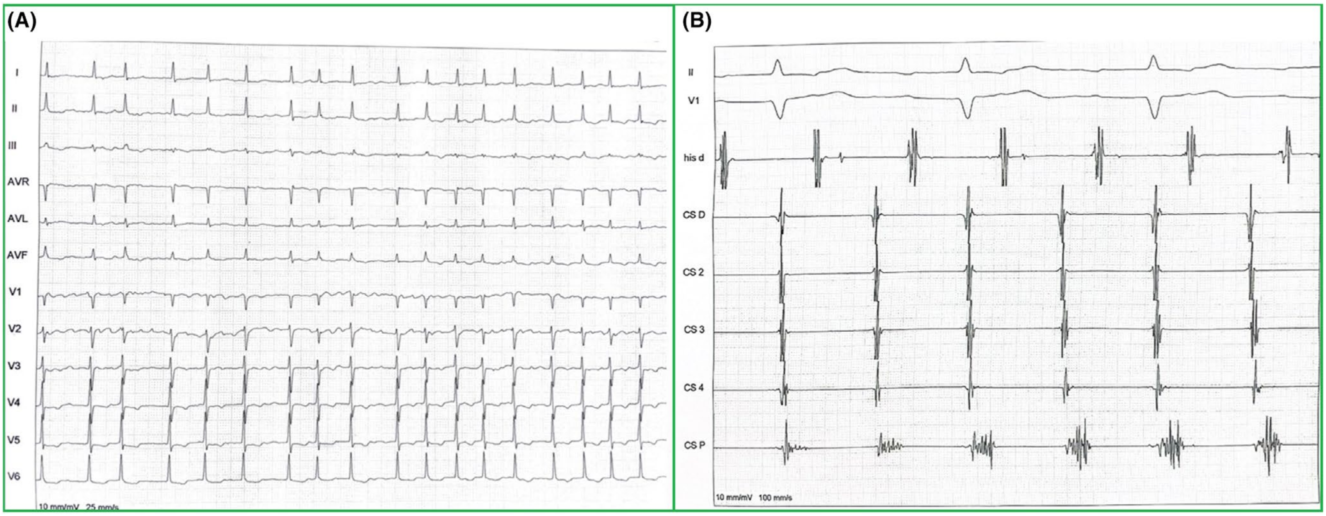

FIGURE 1 Patient's initial electrocardiogram (ECG) (A-left) and intracardiac electrogram (EGM) recording (B-right). A. The ECG demonstrates features of an atrial arrhythmia with an irregular ventricular response. The negative P wave in lead I and the positive P wave in lead V1 suggest a left atrial tachycardia. B. An eccentric coronary sinus (CS) activation pattern (distal to proximal) was observed, indicating a left atrial origin. Therefore, left atrial mapping was planned as the initial approach.

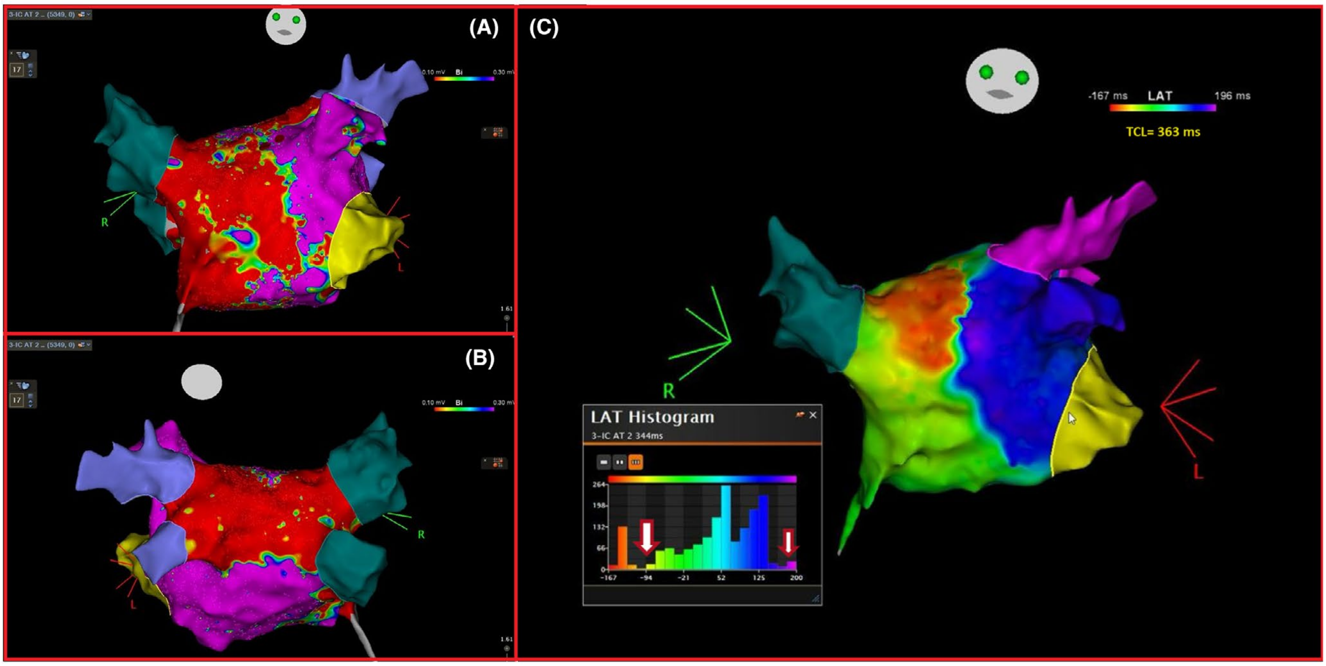

FIGURE 2 Preablation comprehensive left atrial mapping (A–C). (A and B) In voltage mapping, electrical isolation of the ablation line around the pulmonary veins and posterior wall is evident. (C) Local activation time (LAT) mapping and histogram of the patient showing a macrorentrant AT with, CL 358 ms but still missing 35% of tachycardia cycle (TCL) over Bachmann's bundle.

(PA) bifurcation as it anatomically overlies the BB area epicardially. The bifurcation point was found just 7–8 mm above the initial endocardial termination site, where a very small far-field electrogram could still be detected. Taking advantage of this favorable proximity, we applied RF energy at 40 W/30 mL irrigation for 2 min (Figure 3, Video S4 and Figure S1). The AT became noninducible without any complications.

Postprocedural ECG monitoring revealed evidence of partial interatrial block and the patient has remained free of recurrence or symptoms for the past 8 months (Figure S2).

ATs can be classified into different types based on their mechanisms and characteristics, aiding in accurate diagnosis and treatment. Macro-Reentry AT involves large circuits within the atria, often around scar tissue, presenting as regular tachycardia with

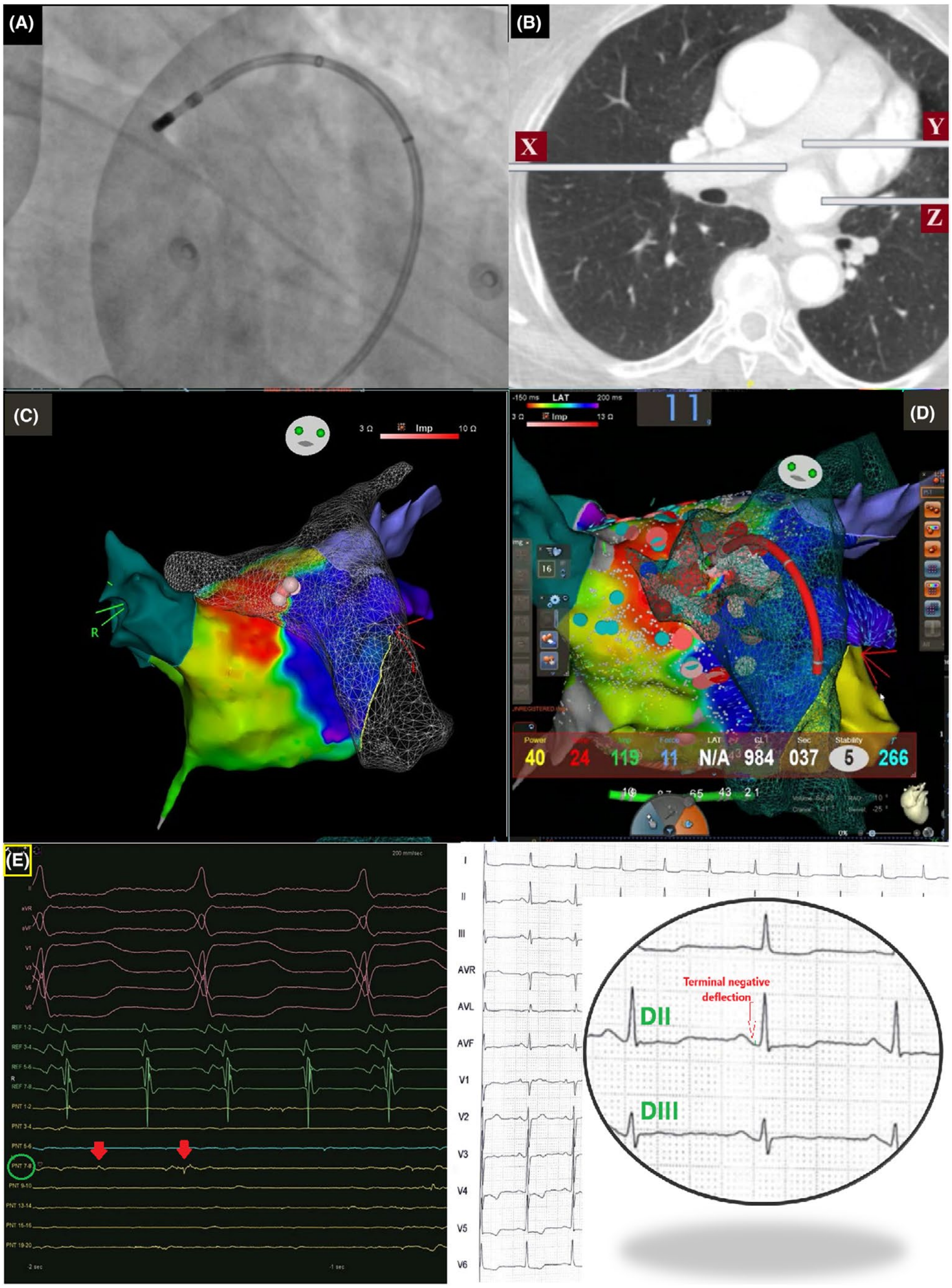

FIGURE 3 (A) Fluoroscopic view of the ablation catheter positioned in the right anterior oblique (RAO) projection at the pulmonary artery bifurcation. (B) Contrast-enhanced cardiac computed tomography image acquired prior to atrial tachycardia (AT) ablation, illustrating the close proximity between Bachmann's bundle (X), the right pulmonary artery (Y), and left atrial cavity (Z). (C and D) The bifurcation point was identified merely 7–8 mm above the initial endocardial termination site, where a faint far-field electrogram (EGM) could still be discerned. On purpose of leveraging from this advantageous proximity, we administered radiofrequency (RF) energy at 40 W/30 mL irrigation for 2 min. The endocardial RF attempts prior to transitioning to the indirect epicardial route can be seen (D). (E) Endocardial far-field signals (from right pulmonary artery) presumed to indicate an epicardial source are observed in the PNT 7–8 bipolar channel. (F) Patient's postprocedure ECG; it was observed that sinus rhythm was restored and partial Bachmann's bundle block (Interatrial block) has developed: Inferior limb leads on the ECG show notching and a prolonged P wave duration (>120 milliseconds), which are indicative of partial interatrial block. If the prolonged P wave is accompanied by a biphasic morphology in the inferior leads, this is termed advanced or complete interatrial block. Postprocedure ECG of this patient reveals partial negativity in the terminal deflection of the P wave and intermittent notching, suggesting a delay in interatrial conduction or the development of an advanced interatrial block.

stable cycle lengths, identified by entrainment maneuvers and activation mapping. The other group of atrial tachycardias is referred to as focal atrial tachycardias; this group includes tachycardias originating from nonautomatic mechanisms, such as enhanced automaticity and triggered activity/micro-reentry, known as nonautomatic focal atrial tachycardias (NAFATs). Micro-Reentry AT features smaller, localized circuits with rapid, irregular activation patterns and variable cycle lengths, distinguished by high-density mapping showing multiple wavefronts.

It is also possible to categorize atrial tachycardias based on the myocardial layer from which they originate; such a classification is particularly important for recognizing the characteristics of epicardial-origin atrial tachycardias-epicardial ATs-and plays a significant role in the success of procedural outcomes by informing different catheter ablation strategies. The distinguishing feature of epicardial ATs involving epicardial bridging tissues is the presence of missing portions of the TCL and often ambiguous endocardial activation maps, which can be challenging to interpret. While many ATs can be terminated by high-power, long-duration RF ablation at the earliest endocardial activation point, typically showing broad centrifugal activation and considered exit/breakthrough sites, unfortunately, some remain inducible. In such cases, operators may opt for contemporary yet unconventional techniques, such as direct epicardial ablation via subxiphoid puncture or ethanol injection into the culprit epicardial structure (e.g., VOM).

Despite inherent risks and less-than-perfect success rates associated with these methods, operator expertise and patient-specific anatomical factors remain crucial determinants of ultimate success. BB originates from the right atrium (RA) at the distal end of the anterior internodal tract. It courses along the superior vena cava (SVC) and the RA appendage toward the LA, encircling the left atrial appendage (LAA) and the left lateral ridge. BB consists of a prominent epicardial layer, crossing anterior to the SVC across the interatrial septum to reach the anterior LA wall, where it bifurcates before extending toward the ridge between the LAA and the left superior PV (LSPV). The failure of prior long-duration, high-power endocardial RF ablation attempts to terminate atrial ATs may be attributed to the substantial thickness of the LA roof containing BB and potential interspersed adipose tissue within the septopulmonary and septoatrial bundles along the roof.[1] These factors may hinder effective energy delivery to the epicardium. Pulse Field Ablation (PFA) could potentially offer success, although it was not available during our procedure. However, although there are studies showing that PFA can create an ablation lesion with less damage to deeper and arterial structures compared with RF ablation, there have not yet been strong studies shared that would impact routine practice in atrial tachyarrhythmia ablation.[2–5]

The anterosuperior LA region near the right PA includes BB and the proximal aspect of the septopulmonary bundle. Therefore, mapping the PA bifurcation region and proximal right PA can provide an indirect epicardial approach to ablate epicardial AT sources in the LA.[6–8] However, this approach carries risks of damaging adjacent structures (sinoatrial node, left main coronary artery, and the PA itself) because of the thinness of the PA wall. Additionally, complete block of BB can lead to RA-LA uncoupling, a potential complication. Although the full clinical significance of BB block remains unclear, studies suggest that because of its potential for longitudinal dissociation, it can facilitate re-entry and increase the risk of atrial fibrillation development.[9] Nonetheless, as observed in our case, achieving procedural success and preventing biatrial/perimitral flutter required planned transmural ablation of the BB line. However, because of tissue thickness, as evidenced by the postprocedural ECG (Figure 3F), this was only partially achieved.

In the literature, effective RF energy application from regions showing early atrial activation signals on anatomically adjacent structures during epicardial AT ablation via BB through the PA has been emphasized, as reported in two previous cases.[3,4] In contrast to these cases, we initially expanded the endocardial ablation lesion set in both the anterior superior septum region adjacent to BB and the posterior wall where the septopulmonary bundle breakthrough point could be located. We then applied energy from an indirect epicardial site to successfully achieve complete transmurality. Additionally, We documented the development of interatrial block in the postprocedural ECG, which can serve as a predictor of procedural success in achieving transmural ablation and preventing the development of perimitral/biatrial tachycardia (Figure 3F).

In conclusion, with a thorough understanding of LA structures, epicardial ATs resistant to endocardial treatment can still be successfully ablated without direct pericardial entry. Thus, RF ablation through the PA appears feasible and effective for BB-related ATs, provided the earliest endocardial points can be accessed via the PA. Nevertheless, its safety and efficacy require validation in larger, randomized studies.

CONFLICT OF INTEREST STATEMENT

The named authors have no conflict of interest, financial or otherwise.

CONSENT

The authors confirm that written consent for submission and publication of this case report, including imaging and associated text, has been obtained from the patient's family in line with COPE guidance.

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SUPPORTING INFORMATION

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