Biatrial flutter circuit involving an anomalous insertion of the Bachmann bundle into the superior vena cava

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Introduction

Prior cardiac surgery or ablation for atrial fibrillation (AF) can predispose patients to the development of atypical atrial flutters, which usually originate from either the left or right atria (LA or RA). Although the coronary sinus (CS) activation sequence can be either concentric or eccentric depending on the circuit, an eccentric activation pattern usually predicts an atypical atrial flutter from the LA. In addition, atrial flutters are rarely dependent on both atria; usually one atrium contains the driver, and the activation of the other atrium is passive. In this case report we describe a unique atypical atrial flutter with an eccentric CS activation pattern that involves both the LA and the RA, utilizing an anomalous connection between the superior vena cava (SVC) and the Bachmann bundle (BB).

Case report

A 62-year-old woman with prior bioprosthetic aortic valve replacement and highly symptomatic persistent AF and atrial flutter, who had undergone 3 prior ablation procedures, presented for repeat ablation. In 2015, she underwent cryoballoon AF ablation. In 2016, she underwent radiofrequency ablation for both typical and atypical atrial flutters. Multiple linear ablation lines were created: cavotricuspid isthmus, anterior mitral line from the septal mitral annulus to the right superior pulmonary vein, LA roofline, and LA floor line. Because of recurrent atrial flutter, a third ablation procedure was performed in April 2017. All 4 pulmonary veins remained isolated. The prior cavotricuspid line, roofline, and anterior mitral lines had preexisting bidirectional block. A gap in the floor line was ablated. During this procedure, she was incidentally found to have an anomalous connection between BB and the septal SVC. This was characterized by pacing the LA appendage while activation mapping the RA (Figure 1), showing earliest activation in the RA from within the SVC. Since this was not found to be involved in any inducible arrhythmias, it was not targeted for ablation. Postprocedure she developed incessant atrial flutter that persisted despite multiple cardioversions and amiodarone.

In August 2017, she underwent her fourth ablation procedure. She presented in atypical atrial flutter with a tachycardia cycle length (TCL) of 305 ms with clockwise rotation around the mitral annulus. Entrainment indicated participation of the distal CS (Figure 2A) and proximal CS in the flutter circuit, with concealed fusion and postpacing interval (PPI)-TCL <30 ms. However, unexpectedly, RA entrainment indicated participation of the high septal RA and SVC, also with concealed fusion and PPI-TCL <30 ms. Despite pacing the SVC faster than intended at 280 ms (TCL = 339 ms), the PPI-TCL was still <30 ms, with late downstream advancement at adjacent sites in the RA (Figure 2B). Activation mapping captured 96% of the flutter cycle length, and was consistent with a biatrial flutter circuit, with activation clockwise around the mitral annulus, crossing the interatrial septum to the septal RA, to the SVC, and back to the superior LA via the anomalous SVC to BB connection (Figure 3A).

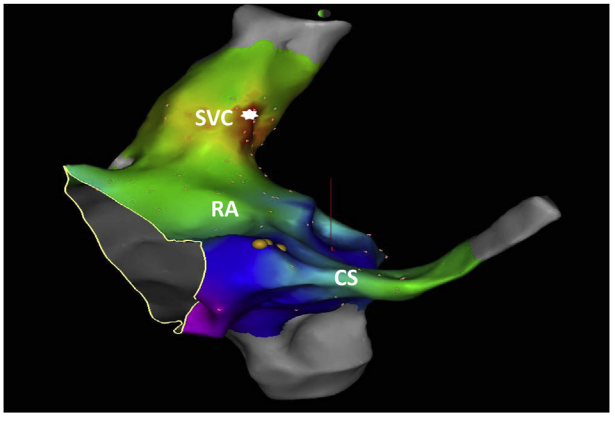

Figure 1 Anomalous connection from the superior vena cava (SVC) to Bachmann bundle (BB) demonstrated by activation mapping of the right atrium (RA) and SVC while pacing the left atrial appendage. The *asterisk* denotes insertion of BB into the SVC. CS = coronary sinus.

KEYWORDS Atypical atrial flutter; Bachmann bundle; Biatrial flutter; Biatrial tachycardia; Superior vena cava
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KEY TEACHING POINTS

- Prior cardiac surgery or atrial fibrillation ablation can predispose patients to the development of atypical atrial flutter.
- Although an eccentric coronary sinus activation pattern during atrial flutter suggests a left atrial circuit, entrainment from the right atrium should still be performed to exclude a biatrial flutter circuit.
- Suspicion for biatrial flutter should be heightened in the setting of prior cardiac surgery or extensive ablation in the anteroseptal left atrium, as it can promote reentry over Bachmann bundle superiorly and the interatrial septum inferiorly.
- We report a unique biatrial flutter that involves an anomalous insertion of Bachmann bundle into the superior vena cava, which was successfully ablated with superior vena cava isolation.

The LA insertion of BB was targeted for ablation, which resulted in transient flutter slowing during ablation from 305 to 340 ms, which was not durable. Because of the unique anomalous insertion of BB into the septal SVC, SVC isolation was performed while pacing the right phrenic nerve to monitor for phrenic palsy. Electrical cardioversion was performed in order to map the sinus node before ablation to avoid injury. The SVC was successfully isolated, rendering the atrial flutter noninducible (Figure 3A). The prior pulmonary vein isolation, posterior box, and linear ablation procedures were demonstrated to be complete. The patient has remained in normal sinus rhythm, off antiarrhythmic medications, at 6-month follow-up.

Discussion

Atypical atrial flutters and atrial tachycardias are common iatrogenic arrhythmias occurring as a consequence of AF ablation, specifically in the setting of circumferential pulmonary vein isolation. Extensive LA ablation procedures can be proarrhythmic, leading to predominantly left-sided arrhythmias, which can be either macroreentrant or focal.[1,2]

Here we present a patient who had undergone extensive prior LA ablation, with subsequent incessant atrial flutter with eccentric CS activation. At first glance, this would be assumed to be an LA circuit, where mapping and ablation efforts would usually be focused. However, entrainment mapping of both the LA and the RA revealed that this was in fact a biatrial flutter circuit. Ip et al[3] described a patient who had extensive cardiac surgery who presented with biatrial flutter with counterclockwise tricuspid activation and counterclockwise mitral activation, which terminated with cavotricuspid isthmus ablation. In our patient, the biatrial flutter circuit did not involve the cavotricuspid isthmus, which was proved to be remote by entrainment. The circuit had clockwise mitral activation, crossed the interatrial septum to the septal RA into the SVC, and was dependent on an anomalous connection between the septal SVC and BB, leading back to the LA. This is, to our knowledge, the first description of such a connection from the SVC to BB.

BB is a parallel aligned bundle of myocardial strands that stretches subepicardially across the interatrial groove and is the main pathway of interatrial conduction between the RA

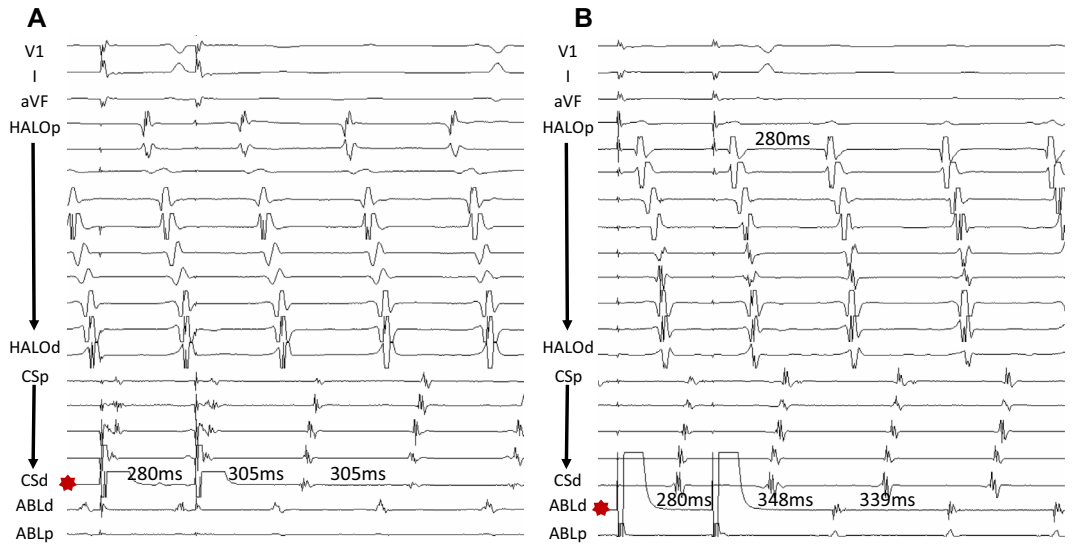

Figure 2 **A:** Entrainment from the distal coronary sinus (CSd) with concealed fusion and postpacing interval-tachycardia cycle length (PPI-TCL) = 0 ms. **B:** Entrainment from the superior vena cava with concealed fusion and PPI-TCL = 9 ms. Despite the close proximity of the proximal HALO catheter (HALOp; Boston Scientific, Marlborough, MA) pole to the superior vena cava pacing site (distal ablation catheter [ABLd]), late activation is seen, noted by the advancement of the HALOp electrogram to the pacing cycle length of 280 ms. This indicates late downstream activation of the HALOp site in the reentrant atrial flutter circuit. Red asterisks denote pacing sites. Positioning of the HALO catheter in the right atrium and coronary sinus catheter is illustrated in Figure 3A. ABLp = proximal ablation catheter; CSp = proximal coronary sinus; HALOd = distal HALO catheter.

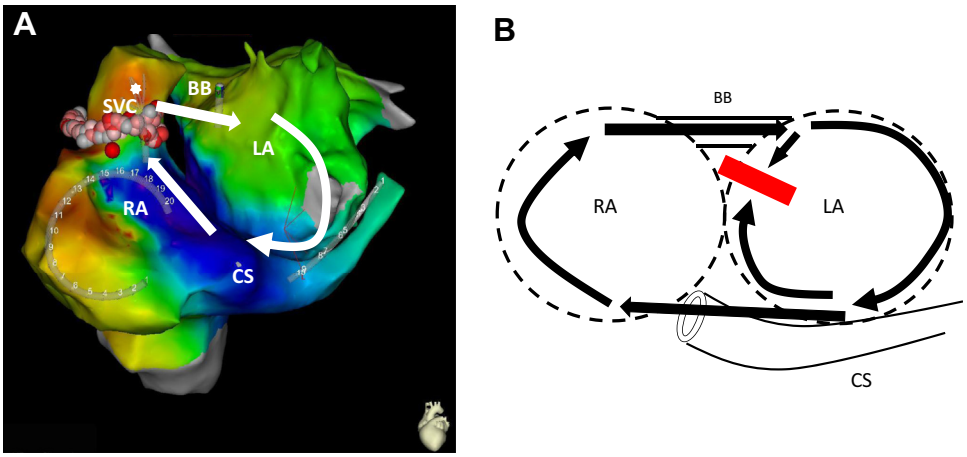

Figure 3 **A:** Activation map of the biatrial flutter circuit. The asterisk denotes anomalous connection between the superior vena cava (SVC) and Bachmann bundle (BB). By isolating the SVC, biatrial flutter was successfully treated. **B:** After anterior mitral ablation (*red bar*), the substrate for biatrial flutter is established because of conduction block on the left atrium (LA) septum, allowing reentry involving BB and the interatrial septum. CS = coronary sinus; RA = right atrium.

and the LA. Its rightward and leftward extensions bifurcate to pass to either side of the RA and LA appendages, and in the RA, the superior arm of the rightward extension arises in the region of the cavoatrial junction close to the sinus node.[4] In our patient, because BB has an anomalous insertion well inside the SVC, biatrial flutter could be successfully ablated from the RA by isolating the SVC.

This patient's extensive prior LA ablation procedures contributed to the development of biatrial flutter, but in particular, the anterior mitral ablation line was the primary culprit. After anterior mitral linear ablation, typical vertical interatrial septal activation is interrupted, predisposing to biatrial reentry via intact transseptal BB conduction superiorly and the CS and fossa ovalis inferiorly (Figure 3B).[5,6] Kitamura et al[5] described 8 patients with biatrial flutter, all of whom had a preexisting electrical obstacle on the anteroseptal LA, primarily from prior ablation lesions. Mikhaylov et al[6] found that of 13 patients undergoing anterior mitral line ablation for perimitral flutter, 4 developed biatrial flutter with clockwise mitral activation, crossing the septum to the RA and back to the LA via BB. These flutters were treated successfully with ablation of BB from the RA anteroseptum in 2 patients and at the LA insertion of BB at the base of the LA appendage in 2 patients. Theoretically, if the anterior mitral line is made more superiorly, transecting the LA insertion of BB, BB-dependent biatrial flutter may be averted, but this has to be further investigated in future studies.

Conclusion

We describe a case of biatrial flutter with clockwise mitral activation, involving an anomalous SVC to BB connection. Although eccentric CS activation typically suggests LA flutter, this case highlights the necessity to entrain from sites in the RA to exclude biatrial flutter, where the target for successful ablation may actually be in the RA, as in this case. Although biatrial flutter is rare, a history of extensive LA septal ablation or cardiac surgery should increase suspicion for this arrhythmia.

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