

SPOTLIGHT

Electroanatomic mapping in atrioventricular junction ablation during sinus rhythm for tachycardia-bradycardia syndrome with persistent left superior vena cava

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A recent publication from our institution was the first description of an electroanatomic mapping (EAM) system to facilitate atrioventricular (AV) junction ablation and pacemaker implantation, or “ablate and pace,” in a patient with permanent atrial fibrillation (AF) and a persistent left superior vena cava (PLSVC).¹ Novel findings for catheter ablation included the abnormal location of the AV node in the right superior AV junction segment and the lack of distinct electrograms at the successful site, which was performed during AF. Herein, we report the first description of AV junction ablation performed during sinus rhythm in a patient with paroxysmal AF and PLSVC. An EAM system was also used.

A 76-year-old woman with paroxysmal AF, Parkinson's disease, and prior lumbar laminectomy for spinal stenosis presented for palpitations and lightheadedness. Her loop recorder (Medtronic, Minneapolis, Minnesota) detected episodes of AF up to 162 beats per minute (bpm) and sinus pauses with ventricular asystole up to 5 s (Figure 1). Outpatient medications included rivaroxaban 20 mg daily, dofetilide 250 mcg twice daily, and metoprolol succinate 25 mg daily. Her left ventricular ejection fraction was 55%–60%.

Cardiac magnetic resonance imaging was obtained due to an initially unsuccessful pacemaker implantation procedure when satisfactory pacing parameters were unable to be achieved and a PLSVC was suspected. The suggestion of a PLSVC with absent right superior vena cava was confirmed and a left-pectoral dual-chamber pacemaker (Boston Scientific) was implanted (Figure 2). She was transitioned from dofetilide to amiodarone, but continued to have breakthrough AF. She was referred for AV junction ablation for

tachycardia-bradycardia syndrome refractory to medical management. Pulmonary vein isolation was not recommended owing to age and co-morbidities.

In the electrophysiology laboratory, one sheath was placed in the right femoral vein. The patient was in sinus rhythm throughout the procedure. A PENTARAY Catheter with the CARTO 3 System (Biosense Webster, Irvine, California) was used to create a reconstruction of the right atrium, coronary sinus, and PLSVC (Figure 3). The PENTARAY Catheter was exchanged for an irrigated 3.5 mm tip THERMOCOOL SMARTTOUCH Catheter (Biosense Webster). Locations with His bundle recordings, at the right superoparaseptal AV junction segment, were tagged.

Radiofrequency ablation commenced with power at 40 W at sites where His bundle electrograms were recorded. These sites were absent of atrial electrograms and had large ventricular electrograms. Because of lack of effectiveness, the catheter tip was gradually positioned more towards the atrial aspect where His bundle electrograms were no longer seen. This was performed owing to prior reported experience.¹ During ablation lesion #7, transient interruption of AV conduction was observed.

Ultimately, the catheter tip was moved back to a site with a His bundle electrogram and large ventricular electrogram. Ablation lesion #8, delivered for 120 s, was successful with permanent cessation of AV conduction 4.2 s after onset of radiofrequency energy (Figure 4). Following the successful ablation lesion, there was a 30-min observation period. The procedure time was 84 min. The fluoroscopy time was 2.8 min. Amiodarone and metoprolol succinate were stopped on discharge.

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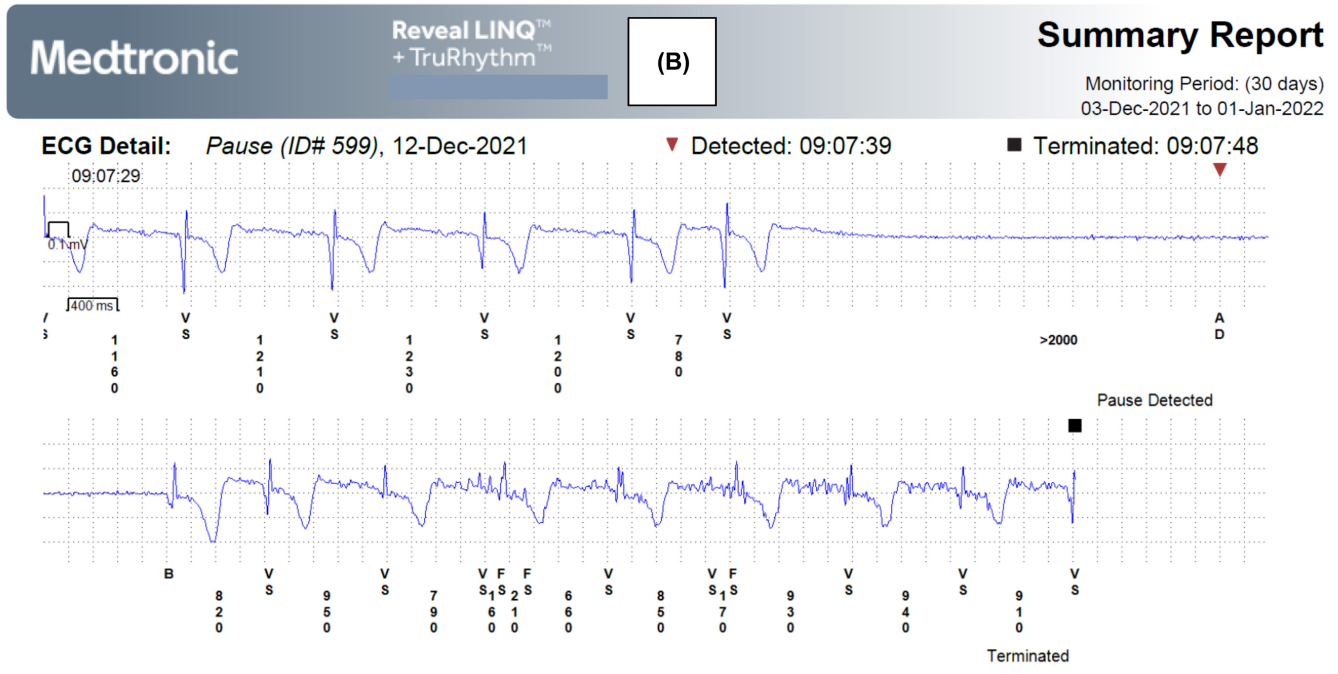
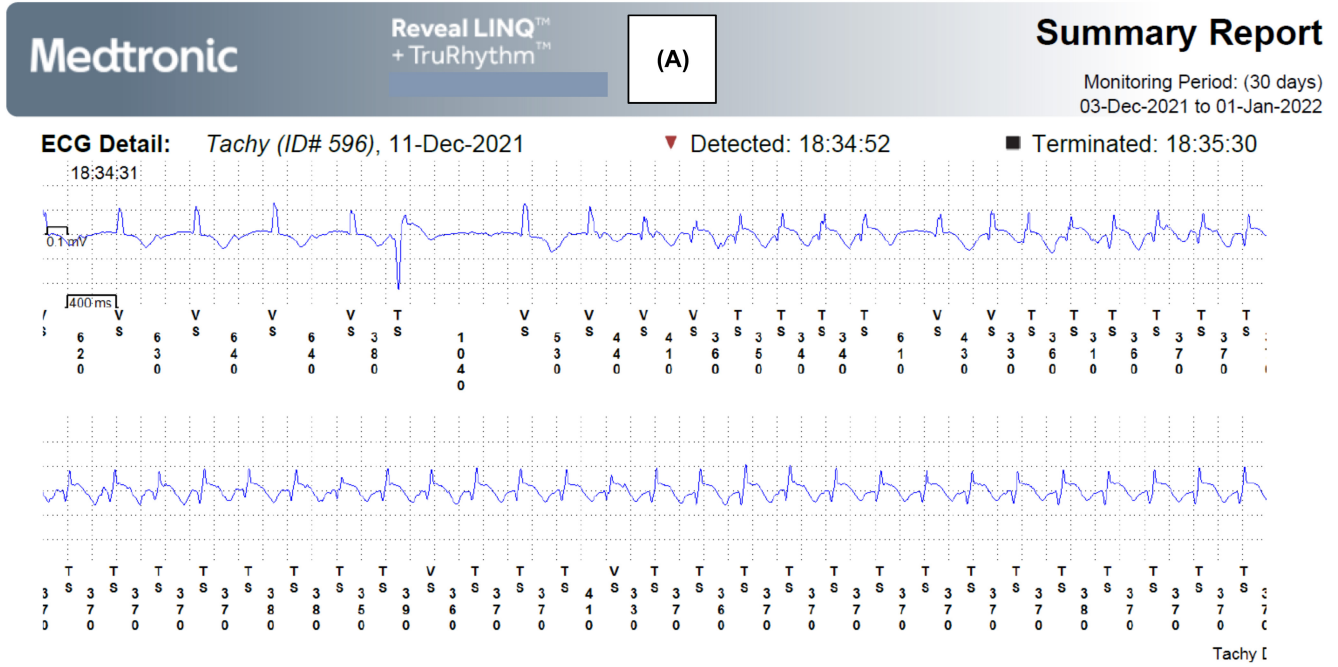


FIGURE 1 Loop recorder transmissions. (A) Initiation of atrial fibrillation with rapid ventricular rate. (B) Sinus arrest lasting 5.0s.

She was doing well at her last follow-up outpatient clinic appointment, which was 13 weeks after catheter ablation. Her lower rate limit was decreased from 80 to 70bpm.

Complete AV junction ablation can be accomplished by targeting either the compact AV node or the His bundle, although the compact AV node is usually favored.^{2,3} In sinus rhythm, ablation of the compact AV node is guided by an AV electrogram ratio of 1:1 and a small, early His electrogram. Radiofrequency ablation leads to an accelerated junctional rhythm followed by complete heart block. In contrast, ablation of the His bundle targets an AV electrogram ratio of 1:2 to 1:5 and radiofrequency

energy results in sudden AV block without a preceding junctional rhythm. A small or an absent atrial electrogram often identifies the right bundle branch potential, as opposed to the His bundle potential.

In this case, the AV node and His bundle were localized to the right superoparaseptal AV junction segment. The successful ablation site demonstrated unusual characteristics. The absence of atrial electrograms at the successful site would suggest a right bundle branch location, yet this was clearly not the case as complete AV block ensued. The accelerated junctional rhythm that preceded complete AV block suggested ablation of the compact AV node. Thus, the area impacted

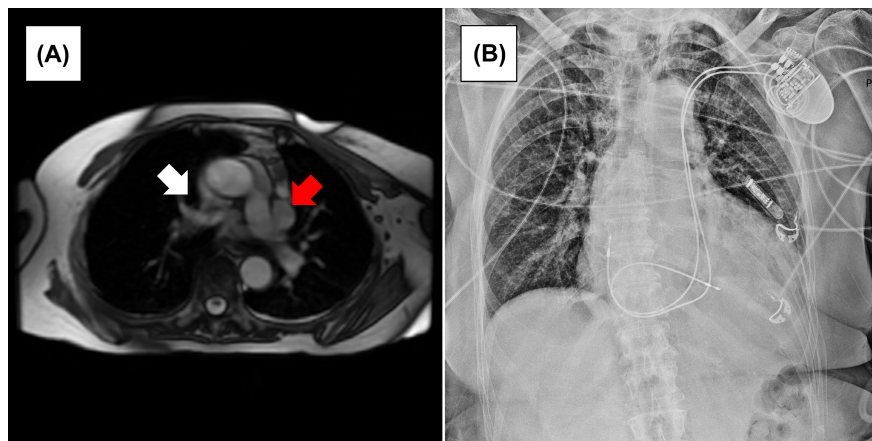


FIGURE 2 (A) Cardiac magnetic resonance localizer image suggested presence of a persistent left superior vena cava (PLSVC) (red arrow) and absence of a right superior vena cava (white arrow). (B) Anterior–posterior chest radiograph following implant of a left-pectoral dual-chamber pacemaker through the PLSVC.

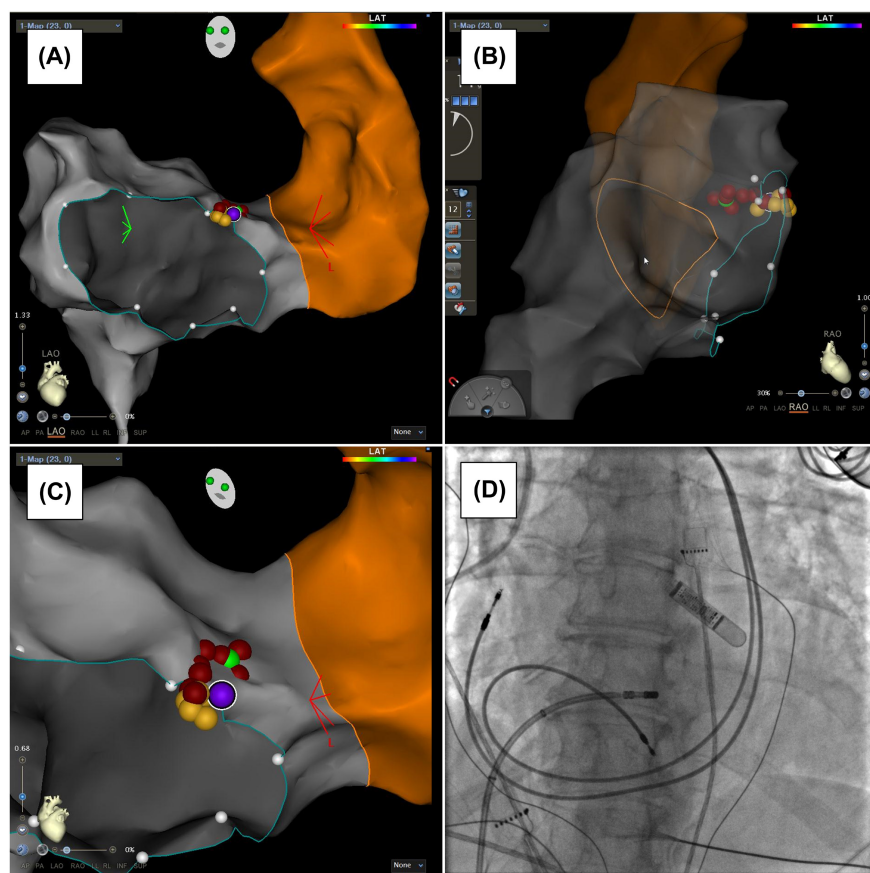


FIGURE 3 Electroanatomic mapping (EAM) for atrioventricular junction ablation. The coronary sinus and persistent left superior vena cava are colored orange. EAM points indicate His bundle recordings (yellow), tricuspid annulus (white), ablation lesions with no effect (red), ablation lesion #7 (green), and ablation lesion #8 (purple). See text for details. (A) Left anterior oblique projection. (B) Right anterior oblique projection. (C) Lesion #8 was delivered at the site of His bundle recordings. (D) Anterior–posterior cine image with the ablation catheter in the successful position, or lesion #8.

by the successful ablation lesion likely involved both the compact AV node and the His bundle.

While conventional AV junction ablation is widely accepted, some individuals have advocated for atrionodal input ablation, a modified AV junction ablation procedure.⁴ This results in an escape rhythm in normal heart rate ranges that accelerates with activity. The procedure involves separate ablation of fast and slow AV nodal inputs with additional ablation to connect the two sites. In PLSVC patients, insights from this case and descriptions of slow AV nodal pathway ablation may increase the feasibility of atrionodal input ablation.⁵

EAM systems are not routinely used for AV junction ablation because of longer preparation time and additional cost. Therefore,

suspicion of a PLSVC on noninvasive imaging should prompt confirmatory testing or proceeding to the electrophysiology laboratory with the assumption that one is present.

Pacemaker implantation and AV junction ablation are commonly performed sequentially as one procedure. When PLSVC is incidentally detected in the course of pacemaker implantation, which is often the case, bringing the patient back on a subsequent day for AV junction ablation with an EAM system is an option. The introduction of an intracardiac echocardiography catheter may also be considered for catheter stability and anatomical clarification, although this has not yet been reported for a patient with PLSVC undergoing AV junction ablation.

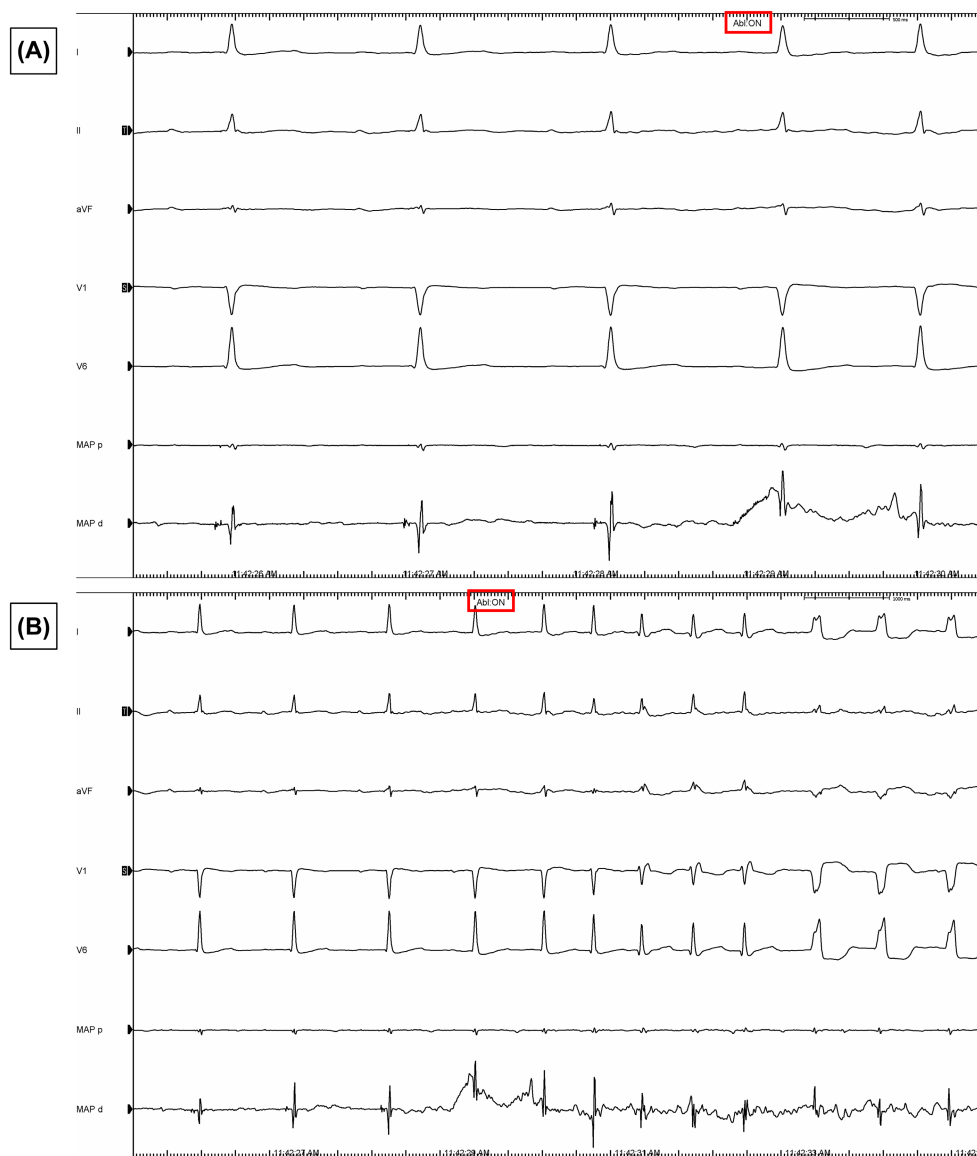


FIGURE 4 Ablation onset at the successful site, lesion #8 (purple dot in Figure 3), is demonstrated by an abrupt change on the ablation catheter recording and indicated by “Abl: ON” (boxed in red). Surface leads I, II, aVF, V₁, and V₆ are displayed. (A) The intracardiac electrogram recording from the distal electrode of the ablation catheter (MAP d) demonstrated no atrial signals but prominent His and ventricular signals. The HV interval measured 50 ms. Recording speed 50 mm/s. (B) An accelerated junctional rhythm appeared with ablation onset. Complete heart block with ventricular pacing occurred at 4.2 s. Recording speed 25 mm/s.

In conclusion, this is the first report describing AV junction ablation during sinus rhythm in a patient with PLSVC. This patient and the prior patient-reported from our institution illustrate the high variability in anatomic and electrogram characteristics for patients with PLSVC who undergo AV junction ablation.¹ EAM systems and awareness of these variations may decrease procedure time, decrease fluoroscopy time, and minimize delivery of ineffective ablation lesions.

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CONFLICT OF INTEREST

Dr. Jain receives research support from Abbott, Boston Scientific, and Medtronic. The remaining authors have no conflicts of interest.

ETHICS STATEMENT

Institutional review board approval was not required given the case report format.

PATIENT CONSENT

Written informed consent was obtained from the patient.

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