Successful fluoroless cardiac resynchronization therapy–pacemaker implantation with left bundle branch area pacing and atrioventricular node ablation via the left axillary vein access using an electroanatomic mapping system

Zhigang Liu, MD, PhD,* Xiaoke Liu, MD, PhD†

*From the *Department of Cardiology, Ascension Borgess Hospital, Kalamazoo, Michigan, and †Department of Cardiovascular Medicine, Mayo Clinic Health System, La Crosse, Wisconsin.*

Introduction

Radiation exposure related to electrophysiology procedures has been drastically reduced with the recent advances in electroanatomic mapping, which makes it possible to perform cardiac ablations with zero fluoroscopy.[1,2] However, such progress has not been made in the area of cardiac implantable electronic device implantation, making radiation exposure remaining to be a major potential occupational hazard to the operators.[3] Cardiac resynchronization therapy (CRT) device implantation especially entails more radiation exposure and thus may pose higher health risk.

The EnSite system (St. Jude Medical, St. Paul, MN) was the dominant mapping system in previous reports attempting to minimize radiation exposure during CRT procedures.[4–6] We recently reported a zero fluoroscopy CRT procedure using left bundle branch area pacing (LBBAP) with the CARTO 3 mapping system (Biosense Webster Inc, Irvine, CA).[7] In this report, we evaluated whether concomitant CRT-pacemaker (CRT-P) implantation via LBBAP and atrioventricular node (AVN) ablation can be performed from the left axillary vein, guided by the CARTO 3 system, without fluoroscopy.

Case report

A 75-year-old female patient with a past medical history of hypertension and hyperlipidemia was admitted to the hospital for persistent atrial fibrillation with rapid ventricular response and shortness of breath consistent with NYHA class III symptoms. Her baseline electrocardiogram showed atrial fibrillation with rapid ventricular response and heart rate 125 beats per minute (bpm). Echocardiogram showed severely reduced left ventricular ejection fraction 30%, moderately dilated left atrium, and severe mitral regurgitation. Left heart catheterization showed normal coronary anatomy without obstructive coronary artery disease. A transesophageal echocardiogram revealed a large left atrial appendage thrombus, leading to abortion of a planned cardioversion. Her laboratory work-up was notable for mild acute kidney injury. Anticoagulation was initiated and a rate control strategy was adopted owing to the presence of left atrial appendage thrombus. The patient was placed on maximally tolerated metoprolol and digoxin. Unfortunately, owing to relatively low baseline blood pressure, and the patient's existing acute kidney injury, it was impossible to optimally control the patient's rapid heart rate through the pharmacologic approach. Her resting heart rate remained higher than 100 bpm and significantly increased with minimal exertion. After a long discussion with the patient about treatment options, decisions were made to proceed with CRT-P implantation with AVN ablation.

After standard left precordium preparation and draping, the patient's left axillary vein was accessed twice under ultrasound guidance without use of fluoroscopy. Two standard

KEY TEACHING POINTS

- Fluoroless cardiac resynchronization therapy implant and concomitant atrioventricular node (AVN) ablation is feasible.
- The CARTO mapping system (Biosense Webster, Irvine, CA) can be used to guide fluoroless device implant.
- The superior approach for AVN ablation may be performed without fluoroscopy.

KEYWORDS Left bundle; His bundle; Cardiac resynchronization; Right ventricular pacing; Fluoroless; AV node ablation
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Address reprint requests and correspondence: Dr Xiaoke Liu, Mayo Clinic Health System, 800 West Ave, La Crosse, WI 54601 E-mail address: liu.xiaoke@mayo.edu.

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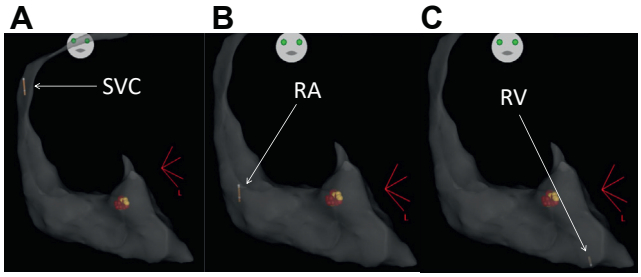

Figure 1 Wire visualization by CARTO (Biosense Webster Inc, Irvine, CA) mapping in the unipolar configuration. **A:** Wire in the superior vena cava (SVC). **B:** Wire in the right atrium (RA). **C:** Wire in the right ventricular apex (RV).

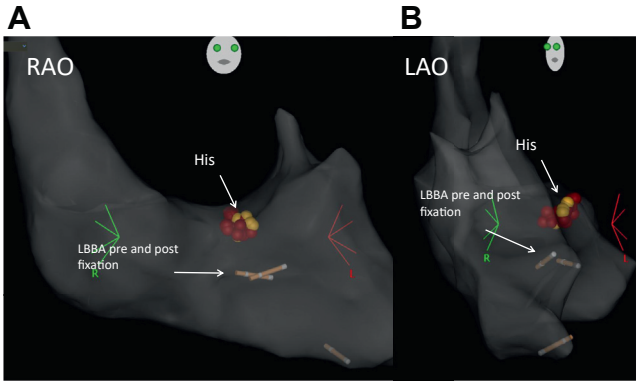

Figure 2 CARTO (Biosense Webster Inc, Irvine, CA) map demonstrating intracardiac anatomy and lead position. **A:** CARTO map in the right anterior oblique (RAO) view. Positions of right ventricular (RV) and left bundle branch area pacing (LBBAP) leads (before and after fixation) and the His bundle area (HIS) are shown. Red dots are ablation points. **B:** The same map in the left anterior oblique (LAO) view showing lead positions in relation to the His bundle area.

J wires were introduced into the left axillary vein, 1 of which was retained to allow access for both right ventricle (RV) and LBBAP lead insertion. First, a 9F introducer was placed, through which a multipolar mapping catheter (Biosense Webster) was inserted to map and create a matrix for the superior vena cava, right atrium (including the right atrial appendage), His bundle area, RV outflow tract, RV septum, and RV apex. An RV pacing lead (4074 CapSure Sense MRI SureScan; Medtronic, Minneapolis, MN) was then inserted and visualized in a bipolar fashion through the CARTO 3 mapping system. The lead was manipulated across the tricuspid valve using a curved stylet and positioned at the RV apex using a straight stylet. Once adequate contact was made based on the CARTO map and the recorded ventricular electrogram, the straight stylet was withdrawn approximately 3 cm while the lead was further advanced toward the RV apex approximately 3 cm to generate adequate forward pressure against the myocardium and to allow enough free lead to safely extend the helix. At this point, the active fixation mechanism was deployed without fluoroscopy. The lead parameters were measured. After confirmation of stable and satisfactory sensing and pacing parameters, the stylet was pulled back approximately 5 cm and an additional 4–5 cm of lead slack was added. The lead was then secured to the underlying tissue using 2 sutures (Figure 1). The RV lead then was connected to the CRT-P generator, which was programmed to VVI mode with lower rate of 40 bpm for backup pacing. A THERMOCOOL SMARTTOUCH ablation catheter was inserted through a long sheath and used to record the His bundle signal and map the AVN position, guided by the CARTO map (Figure 1). After adequate, stable contact with the compact AVN was achieved, ablation was then initiated, at 40 W. After confirmation of complete heart block, the pacing rate was changed to VVI 90 for the rest of the procedure. A C315His delivery sheath (Medtronic) was then advanced through a 7F peel-away sheath with a long J-tip guidewire. The guidewire was advanced into the RV, visualized in a unipolar fashion through the CARTO 3 mapping system (Figure 2), over which the His delivery sheath was advanced into the RV. The 3830 lead (Medtronic) was then advanced through the delivery sheath to the RV septum about 1–1.5 cm distal to the previously tagged His bundle region. The visibility of the 3830 lead in the CARTO 3 system confirmed the lead distal helix exposure from the His delivery sheath. The His delivery sheath and the 3830 lead were manipulated together to ensure perpendicularity against the RV septum when visualized in a bipolar fashion. The tip of the sheath cannot be directly visualized with the CARTO system, but we were able to determine the approximate location of the sheath tip by repeatedly pulling the lead back inside the sheath. As the lead was retracted into the tip of the sheath, it would disappear from the CARTO mapping system. The spot where the lead suddenly disappeared from the mapping system marked the approximate location of the sheath tip. Manual rotations were applied with forward force. Pacing parameters were checked in the unipolar setting after every 1–2 rotations until the paced morphology demonstrated an abrupt change to a relatively narrow right bundle branch block (RBBB) morphology indicating left bundle branch area (LBBA) capture. After several trials, the following parameters were obtained: sensed R wave 8.1 mV, impedance 760 ohms, and pacing threshold 0.5 V @ 0.5 ms. The paced QRS demonstrated a relatively narrow QRS in an RBBB pattern with QRS duration 110 ms (Figure 3A). An additional 7–8 cm of slack was added to the lead after the delivery sheath was sliced in the standard fashion. Once both RV and LBBA leads were implanted, the left precordium was centered in the fluoroscopy field and two brief applicatons of fluoroscopy (less than 10 seconds) were applied to confirm adequate slack of all the leads and full extension of the helixes (Figure 3B). All leads were found to be in satisfactory position with helices extended and adequate slacks.

The device pocket was closed using the standard 3-layer closure technique. The total procedural time, defined as the time from lidocaine injection to closure of the pocket (first 2 layers) by the primary operator, was 72 minutes. No apparent complication was observed. The patient was not required to have bed rest after the procedure because no femoral access was obtained, and was able to ambulate

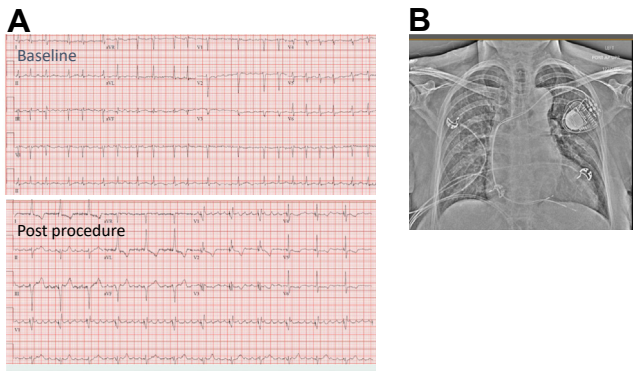

Figure 3 **A:** Twelve-lead electrocardiogram (ECG) recorded at baseline and after cardiac resynchronization therapy–pacemaker implantation and atrioventricular node ablation. Baseline ECG (top) showing atrial fibrillation with rapid ventricular response. ECG recorded postprocedure (bottom) showing a narrow QRS duration of 110 ms with right bundle branch block morphology. **B:** Postprocedural radiograph showing the right ventricular and left bundle branch area pacing lead positions.

immediately upon awakening from anesthesia after the procedure.

The postprocedure electrocardiogram demonstrated a relatively narrow RBBB with QRS duration of 110 ms (Figure 3A). Three months postprocedure, the patient reported significant improvement in heart failure symptoms, with all lead parameters stable compared to those during the initial implantation. A repeat echocardiogram recorded at approximately the same time showed an increase in left ventricular ejection fraction of 50%.

Discussion

LBBAP has rapidly emerged as a promising alternative to His bundle pacing, especially for those expected to have high RV pacing burden.[8–10] LBBAP has the potential advantages of stable lead position and better pacing threshold and sensing, when compared with conventional coronary sinus pacing and His pacing.[11] These advantages make LBBAP possibly a superior choice for patients who are permanent pacemaker dependent, such as those undergoing AVN ablation.[12]

Multiple studies have been conducted to investigate AVN ablation through the axillary vein, and these studies have established multiple inherent advantages of doing AVN ablation through the axillary vein compared to the conventional right femoral approach.[13] This approach is even more relevant in cases involving LBBAP because the His bundle region is typically already mapped prior to LBBA lead implant and the venous access for AVN ablation is also already established. The only additional step required is insertion of an ablation catheter (frequently over a long sheath to enhance stability) to ablate the AVN, guided by the His bundle position already recorded as part of the LBBAP procedure.

To our knowledge, this is the first case report of near-zero fluoroscopy CRT-P system with LBBAP implantation with concomitant AVN ablation from the left subclavian vein using the CARTO 3 mapping system. The feasibility of LBBAP with concomitant AVN ablation through the left axillary vein was previously reported by our group recently.[14] The case demonstrated that fluoroless CRT-P implantation with LBBAP combined with AVN ablation from the left subclavian vein is safe and feasible, and can be achieved with satisfactory acute and short-term clinical outcomes using the CARTO 3 mapping system, which is the system used at most institutions. The EnSite system (St. Jude Medical) is the electroanatomic mapping system used in previous studies.[4,5] Our case here suggests that zero fluoroscopy complex device implantation, such as CRT-P with LBBAP, can be successfully and safely performed with satisfactory clinical outcome guided by the CARTO 3 system in institutions where the EnSite system is unavailable. A larger study is required to further confirm the safety and feasibility of this approach, with the goal of minimizing radiation exposure without compromising clinical outcomes.

In order to minimize the potential risk of inadvertent LBBA lead dislodgement from manipulation of the ablation catheter, the AVN ablation was performed after RV lead implantation but before LBBA lead implantation. By combining LBBAP and AVN ablation from the axillary vein, 2 relatively new electrophysiology approaches, we were able to shorten the total procedure time and achieve an excellent pacing threshold.

In conclusion, this proof-of-concept case demonstrates that concomitant CRT-P and AVN ablation through the superior approach with near-zero fluoroscopy exposure can be safely and efficiently achieved with satisfactory clinical outcomes.

Study limitations

Although no fluoroscopy was used though the entire initial implantation, we did use 2 brief fluoroscopy applications (<10 s fluoroscopy time) at the end of this case, right before pocket closure, to confirm lead position and allow adequate slack adjustment. We could not completely avoid the possibility that the RV lead was dislodged by the ablation catheter during AVN ablation. Moreover, it was still difficult to get reliable visualization of the lead tip position and orientation in a continuous fashion, which made zero fluoroscopy implantation challenging and required substantial operator experience. Finally, there is a modest additional cost from using the CARTO mapping system to guide the procedure.

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