Successful zero fluoroscopy cardiac resynchronization therapy–defibrillator implantation with left bundle branch area pacing using an electroanatomic mapping system

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Introduction

Recent advances in electroanatomic mapping have drastically reduced radiation exposure related to electrophysiological (EP) procedures and have made feasible the performance of cardiac ablation with zero fluoroscopy exposure.[1,2] However, significant radiation exposure during cardiac implantable electrical device procedures remains a major potential occupational hazard to the operators.[3] Complex cardiac implantable electrical device procedures, especially those involving cardiac resynchronization therapy (CRT) devices, entail more radiation exposure and thus may pose higher health risk.

Previous attempts have been made to minimize radiation exposure during CRT procedures, and the EnSite® system (St. Jude Medical, Saint Paul, MN) was the mapping system used in most of these reports.[4–6] Nevertheless, it is unknown whether such procedures using left bundle branch area pacing can be performed without the use of fluoroscopy in institutions where only the CARTO-3 mapping system (Biosense Webster Inc., Irvine, CA) is available.

We report a case of cardiac resynchronization therapy–defibrillator (CRT-D) implantation with left bundle branch area pacing (LBBAP), guided by the CARTO-3 system without fluoroscopy for lead implantation and fixation.

Case report

A 70-year-old man presented to the EP laboratory for CRT-D implantation. He had a medical history of ischemic cardiomyopathy with left ventricular ejection fraction 20% and New York Heart Association functional class III symptoms.

KEY TEACHING POINTS

- Fluoroless cardiac resynchronization therapy–defibrillator (CRT-D) implant with left bundle branch area pacing is safe and feasible.
- The CARTO mapping system can be used for fluoroless CRT-D implant.
- Minimal fluoroscopy is recommended to inspect leads positioning before pocket closure during fluoroless CRT-D implant.

Baseline electrocardiogram showed sinus rhythm with bifascicular block (right bundle branch block and left anterior fascicular block) and QRS duration of 152 ms (Figure 1A).

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 J wires were introduced into the left axillary vein, one of which was retained to allow access for both right atrial (RA) and LBBAP lead insertion.

First, a 9F introducer as placed, through which a multipolar mapping catheter (Biosense Webster) was inserted to map and create a matrix for the superior vena cava, RA (including the RA appendage), His-bundle area, right ventricular (RV) outflow tract, RV septum, and RV apex. An RV defibrillation lead (Sprint Quattro, Medtronic, Minneapolis, MN) was then inserted and visualized in the 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 (EGM), the straight stylet was withdrawn an additional 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

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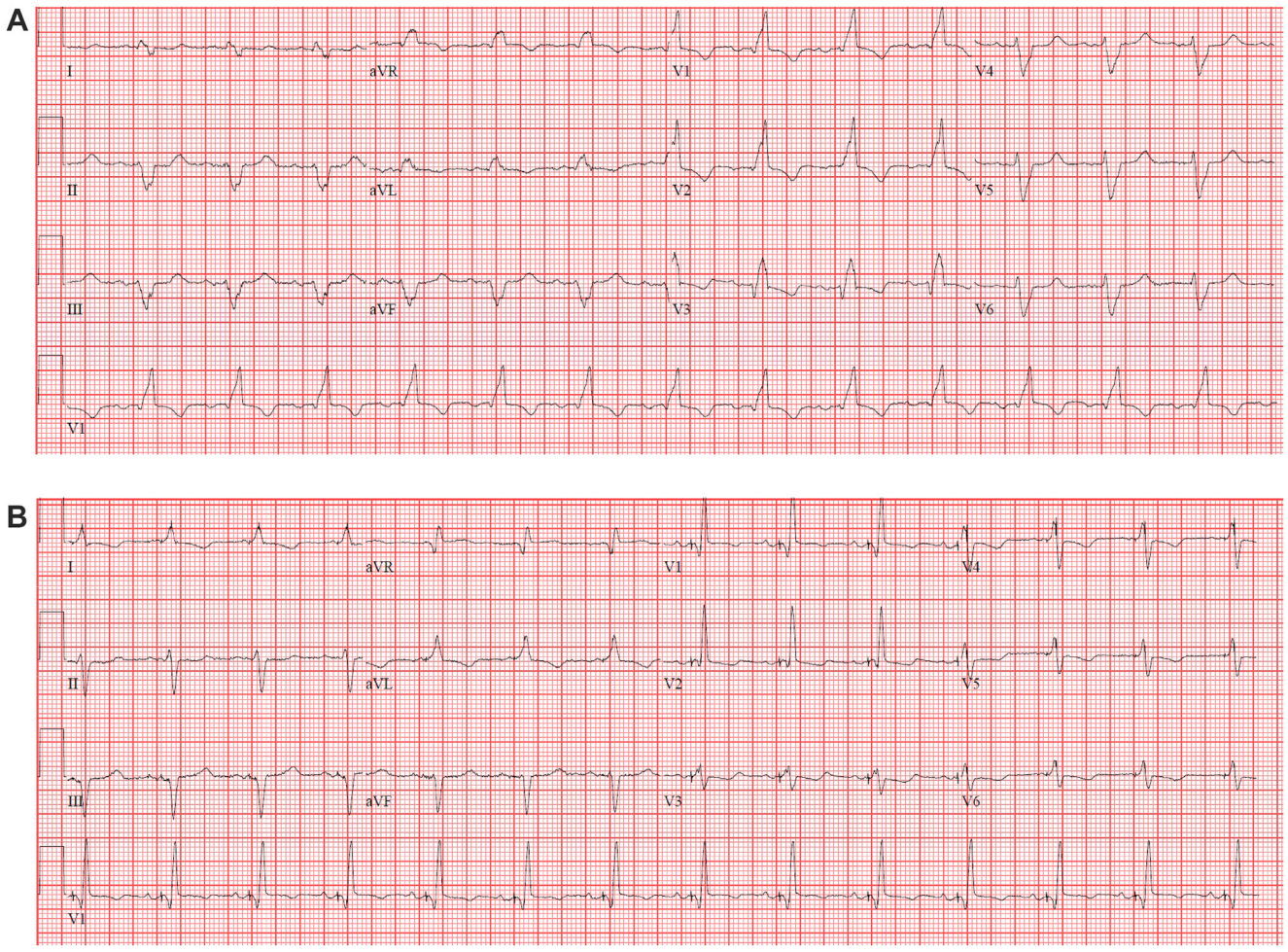

Figure 1 Twelve-lead electrocardiogram (ECG) recorded at baseline and after CRT-D implantation. **A:** Baseline ECG showing bifascicular block with wide QRS duration of 152 ms. **B:** ECG recorded postprocedure showing a much narrower QRS duration of 110 ms with right bundle branch block morphology.

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 1 suture (Figure 2).

A C315His delivery sheath (Medtronic) was advanced through a 7F peelaway 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, 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 the 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 wire/lead back inside the sheath. As the wire or lead was retracted into the tip of the sheath, it would disappear from the CARTO mapping system. The spot where the wire/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 >10 mV, impedance 650 Ω, and pacing threshold <1 V @ 0.5 ms. The paced QRS demonstrated a relatively narrow QRS in an RBBB pattern with QRS duration ≈ 110 ms. An additional 7–8 cm of slack was added to the lead after the delivery sheath was sliced in the standard fashion (Figure 2).

The RA lead (CapSureFix Novus 4076-52 cm, Medtronic) was visualized in a bipolar fashion with the CARTO system. A standard J-curve stylet was used to navigate the lead tip into the RA appendage. Once an acceptable RA EGM was recorded and lead position was verified, the lead was advanced

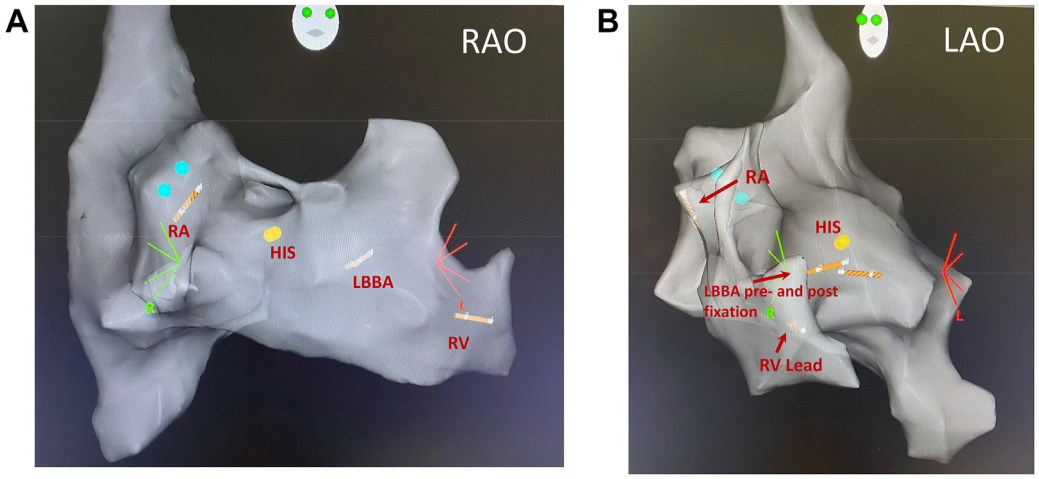

Figure 2 CARTO map demonstrating intracardiac anatomy and lead position. **A:** CARTO map in the right anterior oblique (RAO) view. Positions of the right atrial (RA), right ventricular (RV), and left bundle branch area (LBBA) pacing leads (before and after fixation), and the His-bundle area (HIS) are shown. **B:** Same map in the left anterior oblique (LAO) view showing lead positions in relation to the His-bundle area.

further into the RA until the EGM started to diminish, which indicated lead departure from the RA wall. This movement could also be visualized with the CARTO system. The lead was then pulled back slowly until the RA EGM first increased in amplitude and then stabilized, as demonstrated by CARTO that the RA lead was pulled against the RA appendage. The helix was extended by applying 12 clockwise rotations on the cathode pin. Adequate sensing and threshold parameters were obtained with the stylet being pulled back (Figure 2).

Once all 3 leads were implanted, the left precordium was centered in the fluoroscopy field and a single shot of fluoroscopy (<1 second) was applied to confirm adequate slack of all the leads and full extension of the helixes (Figure 3). All leads were found to be in satisfactory position with helixes extended and adequate slacks. The leads were secured to the underlying tissue and connected to the CRT-D generator. The device pocket was closed using the standard 3-layer closure technique. Total procedural time, defined as the time from lidocaine injection to closure of the pocket (first 2 layers) by the primary operator, was 60 minutes. No apparent complication was observed.

Postprocedure electrocardiogram demonstrated a relatively narrow RBBB with QRS duration of 112 ms (Figure 1B). Two 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 systolic function (ejection fraction 35%).

Discussion

Despite the drastic progresses made in the last decade in reducing radiation exposure in the EP laboratory during ablation procedures, fluoroscopy still is frequently required for cardiac device implant. Complex device implantations, such as for CRT devices and/or LBBAP leads, frequently entail substantial fluoroscopy time. It is important to note that during most device implantation cases, the operator is much closer to the x-ray source and therefore is much more vulnerable to radiation hazard than in ablation procedures using the femoral approach. The current case report is designed to explore the possibility of CRT-D implantation using the LBBAP approach, with zero radiation exposure, guided solely by the CARTO-3 mapping system. To our knowledge, this is the first case report of zero fluoroscopy CRT-D system with LBBAP implantation (a single fluoroscopy shot applied after successful lead placement to confirm lead position, without additional adjustment afterward) using the CARTO-3 mapping system. The case demonstrated that fluoroless CRT-D implantation with LBBAP is safe and feasible, and can be achieved with satisfactory acute clinical outcome using the CARTO-3 mapping system, which is the system used at most institutions.

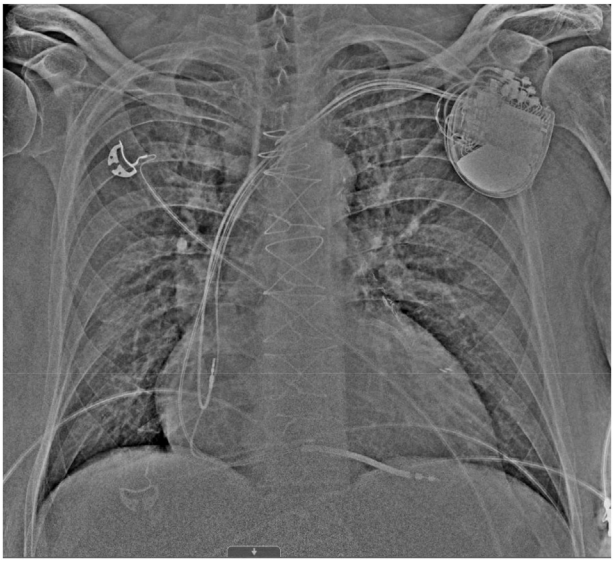

Figure 3 Postprocedure radiograph showing the right atrial, right ventricular, and left bundle branch area pacing lead positions.

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-D 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 study involving multiple patients will help to determine the success rate of this approach, with the goal of minimizing radiation exposure without compromising clinical outcomes.

Study limitations

Even though the entire initial implantation was performed completely without fluoroscopy, we used a single fluoroscopy shot at the end of this case to confirm complete helix extension and adequate lead slack. In addition, achieving reliable visualization of the lead tip position and orientation in a continuous fashion still is difficult with the currently available technology. This may make zero fluoroscopy implantation challenging and require substantial operator experience in certain cases. Another potential limitation is the added cost of using the CARTO mapping system. However, the recent availability and rapid adoption of reprocessed catheters should help mitigate the increased equipment cost. Finally, the exact distance of the 3830 lead tip from the left ventricular endocardium cannot be determined using the technique described in this case. However, a recent study showed that a unipolar impedance cutoff of 450 Ω has 100% sensitivity in detecting septal perforation. This and changes in other pacing parameters may be used to help minimize the risk of septal perforation/overpenetration.[7]

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