Physiologic Pacing in a CRT-D Platform: A Unique Opportunity to Minimize Hardware

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This case represents the first known physiologic pacing system combining DX lead technology with a SelectSecure 3830 His lead (Medtronic).

Physiologic pacing with permanent His bundle pacing (PHBP) or left bundle branch area pacing (LBBAP) is the preferred means of ventricular pacing, with PHBP being the optimal approach.[1] Until recently, a cardiac resynchronization therapy pacemaker (CRT-P) with a left ventricular (LV) pacing lead implanted via the coronary sinus best approximated physiologic pacing. This approach remains appropriate when a high ventricular pacing burden is anticipated, even in the setting of narrow QRS,[2] but is falling out of favor in the emerging era of conduction system pacing. However, a CRT platform for physiologic pacing is ideal when upgrading a device with a previously implanted right ventricular (RV) apical lead or when an implantable cardioverter-defibrillator (ICD) is also needed.[3] The following case illustrates conduction system pacing in the context of a cardiac resynchronization therapy defibrillator (CRT-D) with a DX ICD lead (Biotronik) for atrioventricular (AV) sequential pacing in lieu of a dedicated atrial lead. This case represents the first known physiologic pacing system combining DX lead technology with a SelectSecure 3830 His lead (Medtronic).

CASE PRESENTATION

The patient is an 82-year-old male with paroxysmal atrial fibrillation and ischemic cardiomyopathy referred for ICD therapy. Left ventricular ejection fraction (LVEF) measured 25%-30%, despite coronary artery bypass graft (CABG) surgery 6 months prior and optimal medical therapy. Episodes of symptomatic bradycardia occurred during sequences of AV block documented by telemetry. The QRS was narrow throughout (Figure 1). In anticipation of a high ventricular pacing requirement, a CRT platform with physiologic pacing seemed advantageous and preferable to a traditional LV lead given the absence of appreciable His-Purkinje system (HPS) disease. With no apparent need for atrial pacing, a DX system (Biotronik) was selected and paired with a SelectSecure 3830 His lead (Medtronic) for conduction system pacing.

This case was performed at one of our peripheral hospitals that does not have a dedicated EP lab, meaning no 3D electroanatomical mapping (EAM) or electrophysiology catheters were available to assist with His localization. This represents the practical reality for many operators as the diversity of institutions in which conduction system pacing is performed continues to expand. A 5-lead ECG was available, with local electrograms only obtainable through the pacing system analyzer (PSA).

Our approach is to begin with the fixed shape C315-HIS Catheter (Medtronic), attempting to

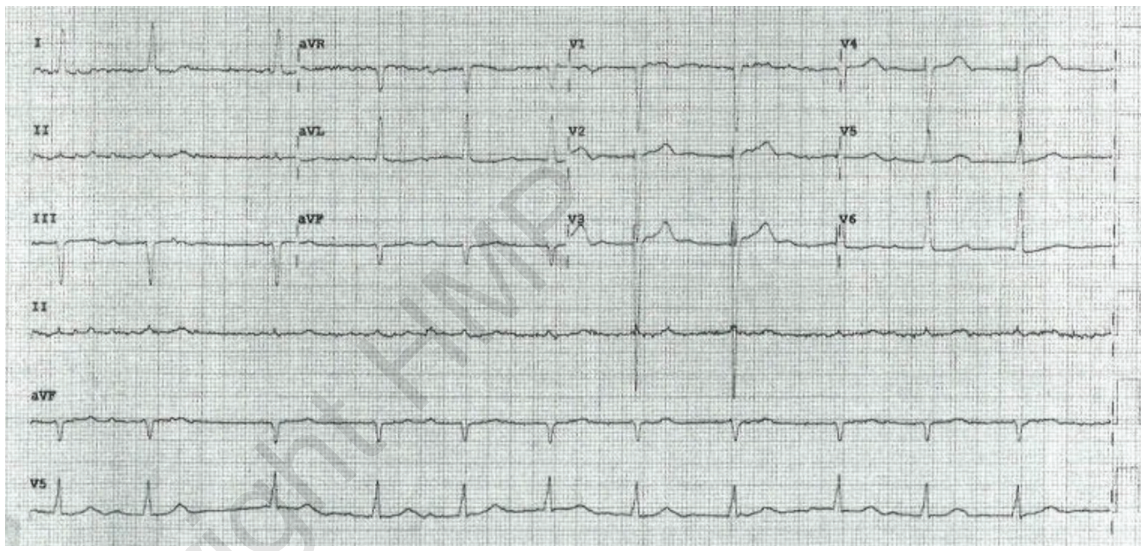

Figure 1. Baseline ECG during an episode of atrial fibrillation. The narrow QRS (QRSD 96 msec) suggests an absence of appreciable conduction system disease. Episodes of symptomatic bradycardia with heart block were observed on telemetry.

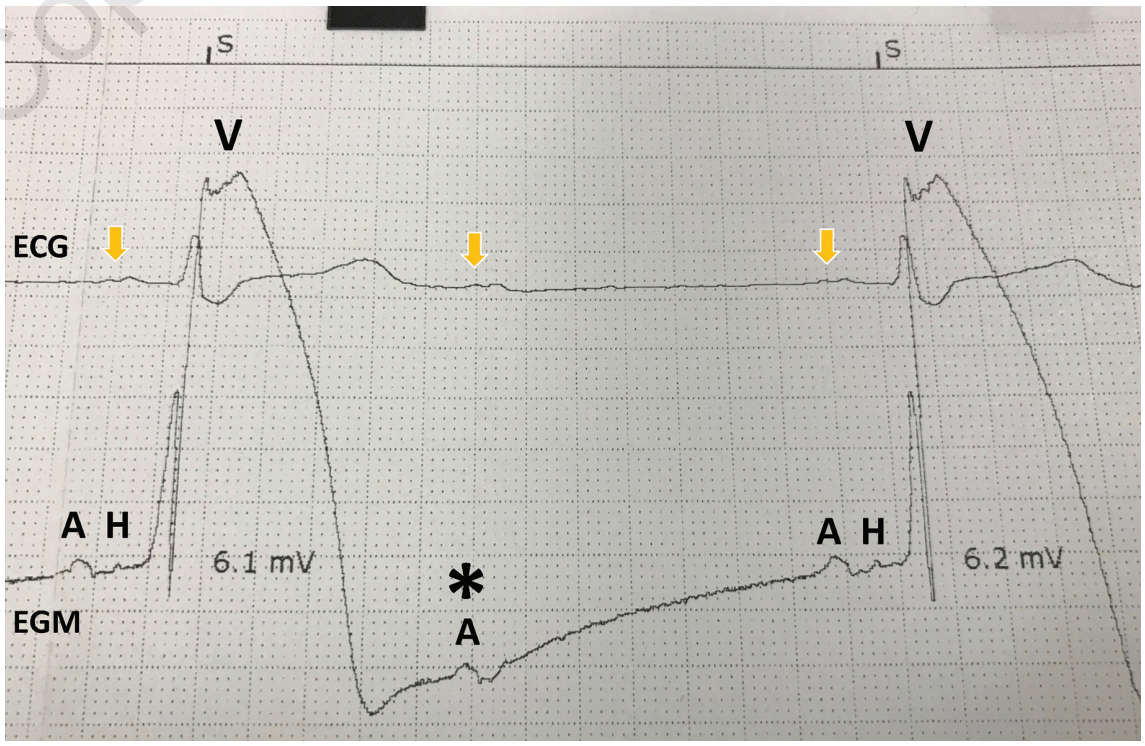

Figure 2. Local electrogram (EGM) with surface ECG lead recorded through the pacing system analyzer (PSA). The atrial component (A) corresponds to the P wave (orange arrows), with His potential (H) preceding the ventricular signal (V). In this recording, 2:1 block with atrial electrogram not followed by a His (*) suggests block at the level of the AV node. Active fixation was achieved using 7-10 revolutions of the 3830 lead (Medtronic) body.

record His potentials from the tip of the 3830 lead. In the presence of complete heart block (CHB), pace mapping is performed to identify sites with narrow paced QRS, suggesting proximity to the conduction system. This technique allows us to anticipate the trajectory of the left bundle branch for LBBAP if needed.[4] If the C315 sheath fails to achieve a sufficiently anterior position, the C304-HIS deflectable sheath (Medtronic) should be substituted. Local electrograms with both atrial and ventricular components indicate an annular location, where a His potential is anticipated (Figure 2). A surface ECG lead through the PSA is helpful in distinguishing between local electrograms. Inadvertent atrial capture is unlikely to occur when the ventricular component is substantially larger than the atrial component. Selective conduction system capture is possible for both HBP and LBBAP, although this may depend on pacing output (Figure 2).[3]

Post-procedure chest x-ray and ECG are shown in Figures 3 and 4. At 3-month follow-up, pacing thresholds were stable from the time of implant, with selective conduction system capture threshold 2.4V @ 1 msec and myocardial threshold 0.8V @ 1 msec. Cardiomyopathy was mildly improved, with a LVEF of 30%-35%. This was attributed to an ongoing positive response to prior revascularization and medical therapy in the absence of deleterious ventricular pacing.

DISCUSSION

RV apical pacing continues to be performed on device patients due to either inappropriate programming or implant strategy. The resulting intraventricular dyssynchrony and compromised systolic contraction may progress to an overt pacing-induced cardiomyopathy (PICM) for pacing burden >20% and paced QRS >150 msec.[4,5] Patients with symptomatic bradycardia typically feel better with RV apical pacing, yet symptom resolution is incomplete. The difference may only be appreciated at the time of pacemaker upgrade to physiologic pacing. This was recently true for a relatively sedentary 96-year-old woman in our practice, who continues to thank us for upgrading her pacemaker. As more electrophysiologists embrace these techniques, physiologic pacing with PHBP and LBBAP is progressively replacing RV apical pacing. Complete adoption will likely reflect the attrition of non-EP implanters from cardiac rhythm management.

Physiologic pacing with a single- or dual-chamber pulse generator is adequate for new implants, although inexperienced operators may wish to implant a backup lead in the RV apical position. This requires a CRT-P pulse generator, with placement of the RV apical lead in the RV port and a PHBP/LBBAP lead in the LV port.[3] An LV offset of 60-80 msec is programmed, so that RV apical pacing falls in the absolute refractory period of the tissue. Should physiological pacing fail for any reason, the backup lead will capture the myocardium. CRT-P devices do not allow the RV lead to be turned off completely; however, the pacing output and pulse duration can be reduced to where any battery drain is negligible. For more experienced operators, good lead characteristics at the time of implant precludes the need for backup, since lead stability is excellent in the His bundle/left bundle branch area locations. A CRT-P platform is advantageous when upgrading a single- or dual-chamber pacemaker for physiologic pacing. This retains the RV apical lead in the pacing system, should it be needed in the future. Similarly, a CRT-D platform allows for physiologic pacing when an ICD is needed.

The floating atrial dipole of the DX system provides dual-chamber diagnostics with a single ICD lead, therefore capturing benefits of both single- and dual-chamber ICDs. The atrial information may be used for the discrimination of supraventricular tachyarrhythmia/ventricular tachycardia, and for the detection of atrial fibrillation episodes. When incorporated into a CRT-D platform, the DX system allows for AV synchronous pacing, and was recently shown to provide equivalent CRT responses with less complications than a conventional three-lead system.[6] The DX system for CRT-D also serves as

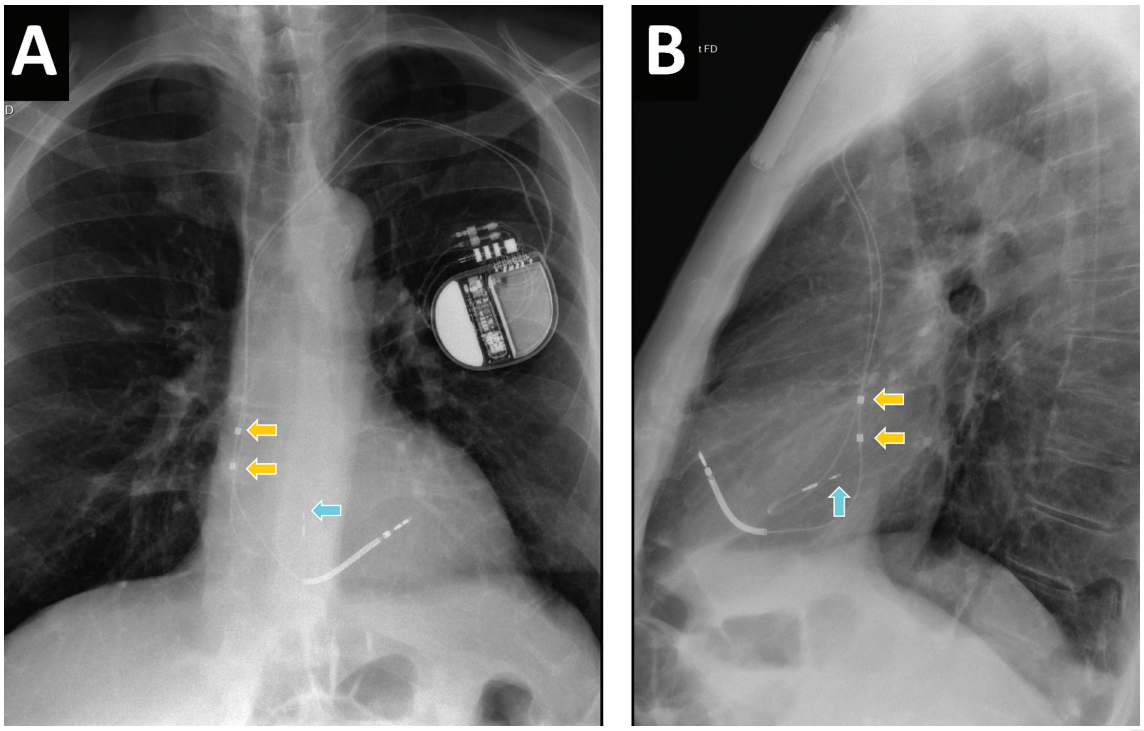

Figure 3. Post-procedure chest x-ray showing the DX system (Biotronik) with SelectSecure (Medtronic) 3830 69-cm His lead, combined using a CRT-D platform. The cardiac silhouette indicates that the floating atrial dipole on the ICD lead (orange arrows) is in the mid-portion of the right atrium (Panel A). The annular position of the 3830 lead (blue arrows) may also be appreciated (Panel B).

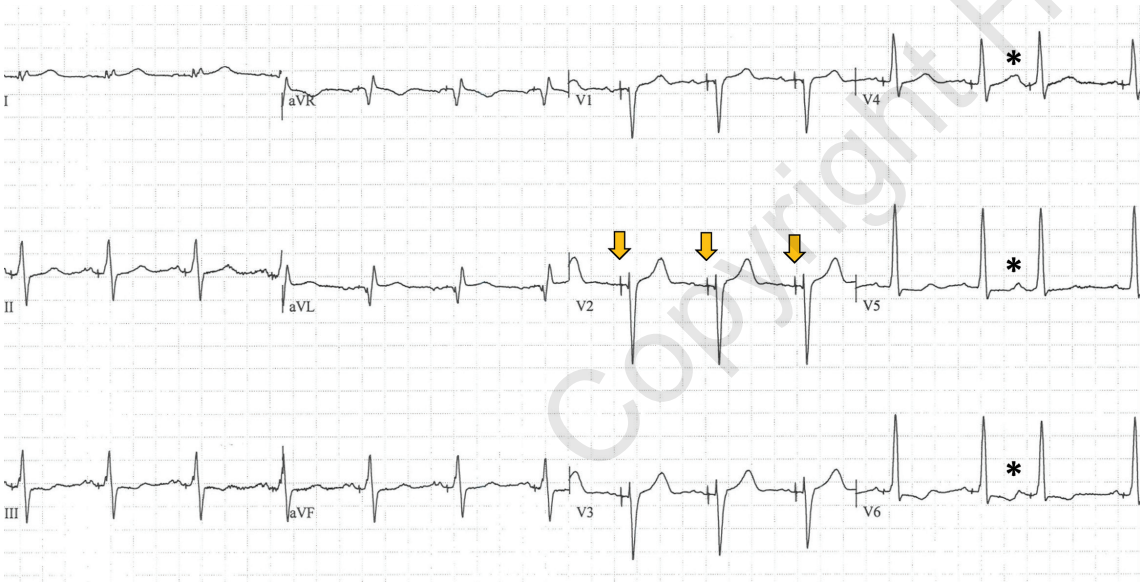

Figure 4. Post-procedure ECG demonstrating physiologic pacing with atrial tracking provided by the floating atrial dipole of the DX ICD lead (Biotronik). The paced QRS morphology matches the baseline QRS (Figure 1), an isoelectric interval between the pacing spike and QRS complex is consistent with specific conduction system capture (arrows). Tracking of a premature atrial contraction (PAC) by the DX system is evident (*).

As more electrophysiologists embrace these techniques, physiologic pacing with permanent His bundle pacing and left bundle branch area pacing is progressively replacing right ventricular apical pacing.

a reminder that atrial pacing should be avoided in heart failure patients, where bradycardia is favored. Recall that ivabradine is licensed for heart failure patients with sinus rates of ≥70 bpm despite beta blockade, with an 18% reduction in all-cause mortality for every 5 bpm reduction in heart rate achieved.[7,8] The DX system is also advantageous in minimizing total lead burden for patients requiring cardiac contractility modulation (CCM [Impulse Dynamics]), which entails two dedicated pacing leads on the RV septum.[9]

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