Inhibition of pacing in a dependent patient with an implantable cardioverter-defibrillator and a left ventricular assist device

Michele Murphy, MD, Timothy Welch, MD, Peter W. Shaw, MD, Jamie L.W. Kennedy, MD, Kenneth C. Bilchick, MD, MS, FHRS

From the Department of Medicine, University of Virginia Health System, Charlottesville, Virginia.

Introduction

Advanced heart failure is the most frequent diagnosis in adult patients admitted to the hospital. The prevalence of heart failure has increased as options for treatment have improved. In addition to pharmacologic therapies, standard implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapy defibrillators (CRT-D) have decreased mortality and improved quality of life. Left ventricular assist devices (LVAD) are also effective therapeutic devices for patients with advanced heart failure,[1] and concurrent therapy with an LVAD and CRT-D is not uncommon. Inappropriate ICD therapy due to electromagnetic interference (EMI) has been reported with LVADs,[2] and ICD–LVAD interactions sometimes require lead repositioning or even device removal.[3] Fortunately, some current ICDs have novel detection and pacing algorithms that can prevent the need for invasive therapy to treat these interactions. The present report adds significantly to the literature on LVADs and cardiac implantable electronic devices by demonstrating how certain ICDs may be programmed to preserve appropriate pacing for bradycardia without compromising the ability of the device to detect and treat ventricular tachycardia and ventricular fibrillation.

Case presentation

A 73-year-old man with ischemic cardiomyopathy, long-standing persistent atrial fibrillation, third-degree atrioventricular block, and advanced heart failure underwent LVAD implantation (HeartMate II; Thoratec, Pleasanton, California) as destination therapy. The patient had undergone CRT-D implantation (St. Jude Medical, St. Paul, Minnesota) a year prior to the LVAD placement. Following the LVAD implant, he had been active at home for more than 2 years. He then presented for hospital admission with progressive low back pain and lower-extremity weakness and was diagnosed with lumbar vertebral compression. Telemetry monitoring demonstrated multiple 2-second pauses despite having the CRT-D programmed DDD with a heart rate of 90 beats per minute (Figure 1A). Evaluation of the CRT-D device (St. Jude Unify Quadra 3249-40) demonstrated atrial fibrillation and normal lead parameters during initial testing. A review of the device electrograms during biventricular pacing and a ventricular sensing amplitude test showed that ventricular pacing was inhibited because of periodic right ventricular (RV) lead sensing of low-amplitude electrograms (Figure 1B). The RV lead impedance and capture threshold were normal. Decreasing the RV pacing sensitivity (increasing the threshold value to a higher number) was not effective in preventing these sensed events because the sensitivity threshold would decay significantly during the time intervals between the previous paced event and low-amplitude signal. What is the most likely cause of these low-amplitude signals? How should the device be reprogrammed to avoid inappropriate inhibition of pacing while preserving appropriate sensing of ventricular fibrillation? Is RV lead repositioning necessary, or is there an appropriate programming change that could fix the problem?

Commentary

Diagnosis

The differential diagnosis in this case includes appropriate sensing or inappropriate sensing from one of the following: myopotentials, ambient EMI, a lead fracture, a loose set screw, mechanical interference from the LVAD, or EMI from the LVAD. A lead fracture was unlikely with the normal impedance, and isometric measures in the pocket did not reproduce the interference. The discrete potentials were also atypical for myopotentials. The 2-dimensional and 3-dimensional computed tomography images (Figure 2) show very close proximity of the LVAD cannula to the RV pacing/defibrillating lead, making it most likely that the

KEYWORDS Ventricular assist devices; Implantable cardioverter-defibrillator; Pacemaker; Cardiac resynchronization therapy; Electromagnetic interference; Bradycardia; Ventricular tachycardia (Heart Rhythm Case Reports 2016;0:1–5)

Address reprints and correspondence: Dr Kenneth C. Bilchick, Associate Professor of Medicine, Cardiology/Electrophysiology, University of Virginia Health System, PO Box 800158, Charlottesville, VA 22908-0158. E-mail address: bilchick@virginia.edu.

http://dx.doi.org/10.1016/j.hrcr.2016.06.008

KEY TEACHING POINTS

- Interactions between left ventricular assist devices (LVADs) and implantable cardioverter-defibrillators (ICDs) are more likely when the sensing lead in a transvenous system or the device in a subcutaneous system is in close proximity to the LVAD cannula.
- The likelihood of this electromagnetic interference (EMI) depends on the type of LVAD implanted and can lead to both inappropriate sensing of ventricular tachycardia and inhibition of bradycardia pacing.
- Typical programming strategies to resolve inappropriate ICD sensing from LVAD-associated EMI, such as adjusting sensitivities, refractory periods, decay delay parameters, or sensing filters interaction, may not be adequate to prevent an invasive device revision procedure.
- When these usual programming strategies are not effective, a novel algorithm that allows setting separate sensitivities for tachycardia detection and bradycardia pacing can resolve these interactions and prevent the need for additional invasive procedures.

signals were caused by EMI from the LVAD or perhaps a mechanical interaction. Furthermore, evaluation of the patient's HeartMate II LVAD showed normal flows and power. Of note, HeartMate II and HeartWare VAD (HVAD; Thoratec, Pleasanton, CA) are the most commonly used LVADs in clinical practice. Although both generate electromagnetic fields, they operate at different pump speeds: 2400–3200 rpm for the HVAD and 8000–12,000 rpm for the HeartMate II. Interestingly, there is not necessarily a proportional relationship between LVAD pump speeds and EMI, as our institutional experience and that of others has been that the HeartMate II less frequently causes EMI compared with the HVAD, even though it uses a higher pump speed, as discussed below in the section "LVAD interactions with other types of ICDs."

ICD–LVAD interactions

Previously identified interactions between ICD and LVADs have included EMI from oversensing of extracardiac signals, which can result in inappropriate therapies.[4] Lead revisions and generator replacements frequently have been required to resolve this problem. As a result, it is recommended that patients have their ICDs checked at the time of LVAD surgery to evaluate EMI. An ICD–LVAD interaction, less frequently seen now, would result in the inability to communicate with older models of St. Jude ICDs.[5,6] These devices used an 8-kHz telemetry frequency, which is close to that of the HeartMate II pulse width modulator. Metal shielding was used to bypass the pulse width modulator of the LVAD and circumvent this interaction, but generator replacement was often required. Of note, the pulse width modulator of the HeartMate II LVAD is used to reduce the 12-volt battery voltage needed to power the motor. More recent ICD models from St. Jude, as well as those made by Biotronik, Medtronic, and Boston Scientific, use a greater telemetry frequency, which makes this type of interaction much less likely.

In our patient, with a newer St. Jude ICD model, telemetry was intact but EMI from the LVAD appeared to be the most likely cause. Initial programming attempts to fix the problem included lengthening the postventricular atrial refractory period, increasing the postventricular atrial blanking period, and reducing the sensitivity, but these interventions were not effective. Because the sensed deflection appeared much later than the prior ventricular event, the sensitivity would decay much sooner and still sense the low-amplitude signal. The other concern about reducing the RV sensitivity was increasing the probability of undersensing of ventricular tachycardia or fibrillation and withholding appropriate therapy for these arrhythmias. Adjusting the decay delay parameter, which determines the amount of time after a sensed or paced event that the sensing threshold remains at the programmed value prior to decreasing, did not resolve the problem because the oversensed electrograms occurred well after the last ventricular event. The high attenuation filter was also considered, but this would have required defibrillation threshold testing and potentially inhibited appropriate sensing of ventricular tachyarrhythmias.

Resolution of EMI interaction in the present case

Considering that standard programming changes did not resolve the problem, it is fortunate that this patient's St. Jude ICD had the SenseAbility algorithm, as it was this algorithm that ultimately resolved the problem. Because many electrophysiologists may not be familiar with this algorithm, we highlight here why it was effective when other measures failed. There are several features of this algorithm that help prevent oversensing of low-amplitude signals. Specifically, this algorithm permits decoupling of ventricular pacing sensitivity and ventricular defibrillator sensitivity. This approach facilitates adjustment of the sensitivity of RV pacing to minimize oversensing without compromising the sensitivity of tachyarrhythmia detection. The device had been programmed at the time of implantation to a nominal ventricular pacing and defibrillation sensitivity of 0.5 mV. To address the inappropriate pacing inhibition during the present admission, the sensitivity for RV pacing was reprogrammed to 2 mV, but the defibrillation sensitivity was maintained at 0.5 mV (Figure 3A), thus allowing for both maintenance of pacing for bradycardia and appropriate detection of ventricular tachyarrhythmias. In other words, the algorithm allows different sensitivities to be programmed for bradycardia pacing and tachyarrhythmia detection. The repeat device interrogation with these new settings revealed