Adverse Interaction Between a Left Ventricular Assist Device and an Implantable Cardioverter Defibrillator

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Implantable Cardioverter Defibrillator, Electromechanical Interference, Ventricular Assist Device. **An increasing number of patients have a coexisting implantable cardioverter defibrillator (ICD) and left ventricular assist device (LVAD) to treat ventricular arrhythmias and refractory heart failure, respectively. To date, there have been no published reports of negative interactions between these devices that have impacted appropriate ICD or LVAD function. In this case report, we describe a patient with an LVAD-ICD interaction that necessitated replacement of the implantable defibrillator.** *(J Cardiovasc Electrophysiol, Vol. 18, pp. 1107-1108, October 2007)*

clinical, implantable devices, ventricular tachycardia/fibrillation clinical, electrophysiology, ventricular tachycardia

Introduction

Implantation of a left ventricular assist device as a bridge to cardiac transplantation or as destination therapy for patients with end stage heart failure is becoming increasingly common. In 2005, approximately 1100 LVADs were implanted in the United States (personal communication with Thoratec, May 2006). Because recent clinical trials have demonstrated the survival benefit of implantable cardioverter defibrillators in patients with heart failure, many LVAD candidates have an ICD in place prior to LVAD surgery.[1,2] While the discharge of an ICD has not been found to impair the mechanical function of contemporary LVADs, little has been published about the impact of electromagnetic interference from LVADs on ICD function. This case report describes a patient with an interaction between his ICD and HeartMate II LVAD that resulted in an inability to interrogate and program the ICD, ultimately requiring replacement of the ICD.

Case Report

A 48-year-old man presented to an outside institution in February, 2006, with an acute anterior myocardial infarction. Cardiac catheterization revealed a left ventricular ejection fraction of 0.10 and occlusion of the left anterior descending and right coronary arteries. A drug-eluting stent was deployed in the left anterior descending artery. His hospital stay was complicated by recurrent ventricular tachycardia (VT). He was treated with intravenous amiodorone and underwent implantation of a single-chamber nonthoracotomy implantable cardioverter defibrillator (Model V193; St. Jude Medical Corporation, Sunnyvale, CA, USA) in the left prepectoral position.

Five days after discharge from the hospital, the patient presented to an outside facility in cardiogenic shock with recurrent ICD therapies requiring reinitiation of intravenous amiodarone. Interrogation of his ICD revealed normal device function, with appropriate shocks delivered for recurrent episodes of ventricular tachycardia. He was discharged from the hospital three weeks later, with oral amiodarone added to his medical regimen.

On April 2, 2006, the patient again presented with recurrent ICD shocks for ventricular tachycardia and was transferred to the University of Michigan Health System for management of his ischemic cardiomyopathy and arrhythmias. During this admission, defibrillation testing demonstrated normal defibrillator function with a defibrillation energy requirement of $\leq$10 Joules. A lack of significant myocardial viability on perfusion imaging and the severe degree of left ventricular dysfunction with hemodynamic derangements led to recommendations for placement of an LVAD as a bridge to cardiac transplantation.

On April 21, 2006, the patient was taken to the operating room for placement of an LVAD. Immediately prior to surgery, his ICD was interrogated and again demonstrated normal device function. Ventricular tachycardia therapies were then disabled. The patient underwent uncomplicated placement of a HeartMate II left ventricular assist device (Thoratec Corporation, Pleasanton, CA, USA). Post-operatively, the HeartMate II pump speed was set at 9400 rpm to provide adequate device flow, pulsatility index, and hemodynamic status. When the electrophysiology team attempted to interrogate and reprogram the ICD following surgery, telemetry between the ICD and the defibrillator programmer could not be established, despite using multiple programmers and programming head positions. Based on recommendations from the ICD manufacturer, six inches of towels were placed over the ICD pocket while the LVAD pump speed was maintained at 9400 rpm. Again, telemetry between the ICD and the programmer was unsuccessful.

Because of the inability to interrogate or reprogram the patient's ICD at the optimal LVAD speed, the ICD generator was removed and replaced with another manufacturer's ICD (Medtronic Inc., Minneapolis, MN, USA). After implantation of the new ICD, programmer-ICD telemetry was established with normal interrogation and programming of the ICD at LVAD

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speeds of 9000–10,000 rpm. Interrogation of the explanted St. Jude ICD was successful and revealed otherwise normal device function.

Discussion

In the 20 years of LVAD use, this case report represents the first description of an adverse interaction between an LVAD and an ICD requiring replacement of the ICD. In this patient, an adverse interaction with the HeartMate II LVAD prevented telemetry communication between the device programmer and the St. Jude ICD. Intrinsic malfunction of the ICD or its programmer is very unlikely, since both devices functioned normally in the absence of the LVAD. Other sources of electromagnetic interference were considered, but the ICD demonstrated normal interrogation and programming in the same environments both before the LVAD implant and after the St. Jude ICD was removed. Potential causes for the problem include electromagnetic frequencies produced during LVAD operation that are similar to the telemetry frequencies used during ICD interrogation, and programming. Another possibility is that the current shielding available in the ICD is insufficient to prevent electromagnetic interference from the LVAD that is placed in proximity to the ICD.

At the University of Michigan Health System, with over 200 LVAD implants to date, this is the first occurrence of an ICD-LVAD interaction. Of the 80 patients implanted with an LVAD device (53% HeartMate I, 35% HeartMate II, 12% other) at our institution since May 2003, 53 (66%) had a preexisting ICD in place at the time of LVAD surgery. Manufacturer data was available on 45 of the 53 ICDs, and 53% (n = 24) were Medtronic, 40% (n = 18) were Boston Scientific (St. Paul, MN), 4.4% (n = 2) were Biotronik (Lake Oswego, OR), and 2.2% (n = 1) were St. Jude.

The St. Jude Corporation acknowledged previous unpublished instances of similar problems with ICD interrogation and reprogramming in patients after HeartMate II implantation (personal communication with St. Jude Corporation, May 2006). According to the company, the malfunction is caused by electromagnetic interference from the HeartMate II LVAD, impairing telemetry communication between the ICD and the ICD programmer. They also reported that while enabled ICDs function normally in the presence of the HeartMate II, the defibrillator may not be able to be interrogated or programmed while the LVAD functioned at the prescribed speeds. St. Jude also reports that the telemetry frequencies for their implantable pacemakers are similar to that of their ICDs.

Other options suggested by St. Jude Medical were to either reduce the HeartMate II pump speed to 1300 rpm or to increase the pump speed to 11,200–12,000 rpm. However, large changes in HeartMate II pump speeds, even if only transient, could be detrimental to the patient. A reduction in LVAD pump speed to 1300 rpm for the few minutes required to complete an interrogation could lead to hemodynamic compromise and even syncope in patients with severe intrinsic left ventricular dysfunction. Similarly, elevated rotary speeds could quickly reduce left ventricular preload, resulting in poor device flows and clinical decompensation. The Thoratec Corporation does not recommend pump speeds over 10,000 rpm with the HeartMate II.

The Thoratec Corporation stated that they were aware of isolated instances of ICD malfunction in HeartMate II recipients and that these problems appeared specific to ICDs manufactured by the St. Jude Corporation (personal communication with Thoratec Corporation, May 2006). Due to the limited data available, it is unclear if ICDs from other manufacturers could exhibit a similar interaction with the HeartMate II. To date, there have been no reported adverse ICD-LVAD interactions with either the Medtronic or Boston Scientific ICDs. Likewise, it is unknown whether this device interaction is limited to the axial flow LVADs, such as the HeartMate II, or if it can also occur with pulsatile flow LVADs.

While an ICD is not routinely implanted in all patients prior to LVAD surgery, reports describing the deleterious hemodynamic and clinical effects of ventricular arrhythmias in these patients support their use.[3,4] With the increased use of mechanical circulatory support, more ICD-LVAD interactions may begin to appear. While St. Jude reports that their new generation of devices (including the Atlas® ICDs) operate at a higher (4 Hz) frequency, allowing for successful telemetry communication between the programmer and the device during HeartMate II support, many LVAD candidates may still have preexisting older St. Jude devices in place. In patients undergoing LVAD evaluation, clinicians should consider the potential for similar interactions between an ICD or pacemaker and an LVAD, and take appropriate steps to ensure that the device can be interrogated and programmed normally after LVAD insertion.

References

1. Bardy GH, Lee KL, Mark DB, Poole JE, Packer DL, Boineau R, Domanski M, Troutman C, Anderson J, Johnson G, McNulty SE, Clapp-Channing N, Davidson-Ray LD, Fraulo ES, Fishbein DP, Luceri RM, Ip JH: Sudden cardiac death in heart failure trial (SCD-HeFT) investigators: Amiodorone or an implantable- cardioverter defibrillator for congestive heart failure. N Engl J Med 2005;352:225-237.
2. Moss AJ, Zareba WJ, Hall W, Klein H, Wilber DJ, Cannom DS, Daubert JP, Higgins SL, Brown MW, Andrews ML: Multicenter automatic defibrillator implantation trial (MADIT) II investigators: Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction. N Engl J Med 2002;346:877-883.
3. Ziv O, Dizon J, Thosani A, Naka Y, Magnano AR, Garan H: Effects of left ventricular assist device therapy on ventricular arrhythmias. J Am Coll Cardiol 1994;24:1688-1691.
4. Harding JD, Piacentino V, Rothman S, Rothman S, Chambers S, Jessup M, Margulies KB: Prolonged repolarization after ventricular assist device support is associated with arrhythmias in humans with congestive heart failure. J Card Fail 2003;11:227-232.