

Inappropriate defibrillator shock during gynecologic electro-surgery



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Introduction

Patients with implantable cardioverter-defibrillators (ICD) who undergo electro-surgery are at risk for electromagnetic interference (EMI) that can lead to oversensing. Oversensing can result in the delivery of inappropriate therapies or inhibition of pacing. The risk of EMI with resultant oversensing is typically affected by the location of the surgery being performed relative to the site of the patient's device.¹ The distance from the surgical site to the device can be estimated by providers; an estimate of at least 6 inches from the presumed current path is used to differentiate a higher-risk surgical zone from further, lower-risk areas.^{1,2} This distance is not necessarily the direct distance to the device, as it can be affected by the placement of the return patch. Current guidelines for ICD management during surgery performed below the level of the umbilicus do not recommend deactivation of tachytherapies prior to the procedure owing to the very low risk of EMI.¹ We present an unusual case of a patient with a left ventricular assist device (LVAD), a fenestrated abdominal aortic graft, and an intermittently elevated ICD lead impedance who received inappropriate ICD tachytherapy owing to EMI that occurred at the time of electro-surgery delivered during a loop electro-surgical excision procedure (LEEP).

Case report

A 52-year-old woman with nonischemic cardiomyopathy and a HeartWare LVAD (HeartWare, Inc, Framingham, MA) implanted 7 months prior underwent a colposcopy with LEEP with moderate sedation. She had a history of abdominal aortic aneurysm that was repaired with a Zenith fenestrated endovascular graft (Cook Medical, Bloomington,

IN) and placement of iCAST stents (Atrial Medical Corporation, Hudson, NH) in the bilateral renal arteries 2 years earlier. She also had a dual-chamber ICD (Boston Scientific, Inc, Marlborough, MA) implanted 12 years prior for primary prevention (lead model numbers 4086 and 0158 from 12 years prior and pulse generator model E110 [Teligen] from 8 years prior) and was followed at an outside institution for device management. At baseline, the patient's device was programmed DDI with lower rate limit of 50 beats per minute (bpm) with 2 therapy zones and therapies—a ventricular fibrillation (VF) zone: 250 bpm, detection duration 1.0 second, and therapy: antitachycardia pacing (ATP) before charging, a 31-joule shock followed by 7 41-joule shocks; and a ventricular tachycardia (VT) zone: 200 bpm, detection duration 2.5 seconds, and therapy: ATP with scan scheme, followed by ramp scheme, then a 21-joule shock, and 5 41-joule shocks. Given that the planned surgery was to occur remotely from the ICD, the device was not interrogated prior to the procedure, no programming changes were made, and no magnet was applied. For the procedure, the patient was in the lithotomy position with a grounding pad for monopolar electro-surgery on her right thigh and the LVAD controller resting on her abdomen at the level of the umbilicus. Electro-surgery on the cervix was first performed with blended cut output at 40 watts, without incident. At the end of the case, coagulation output was applied at 50 watts, at which time EMI was sensed by the patient's ICD as a VF event. This led to delivery of ATP, which induced true VT, which was detected in the VF zone and successfully terminated with a 31-joule shock (Figure 1). Much lower-amplitude EMI was also visible on the right atrial lead and, interestingly, only very subtle noise was seen on the shock electrogram (EGM). Of note, sensing on the right ventricular (RV) lead was set to an integrated-bipolar configuration (RV tip to RV coil) while the shock EGM was sensed from the pulse generator to the RV coil. Subsequently, a magnet was placed over the ICD as more electro-surgery was applied at the same settings. EMI occurred again, causing oversensing categorized as a VT event, but no therapies were delivered (Figure 2) owing to the presence of the magnet. Interrogation of the ICD after the procedure revealed normal

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KEY TEACHING POINTS

- Current guidelines do not recommend device reprogramming for electrosurgical procedures performed >6 inches from a cardiac implanted electronic device.
- Presence of additional metal implants may lead to unexpected electromagnetic interference.
- Evaluating past trends in impedance prior to surgery may be helpful in discerning additional information about lead status.

measurements, including impedances in all leads, normal RV pacing, and shock impedances. However, examination of the pacing impedance trends revealed intermittent measurements of >2500 ohms dating back to at least 1 year prior (several months prior to LVAD implantation). No nonsustained VT episodes suggestive of lead fracture or “chatter” were noted in the arrhythmia log. Pocket manipulation and upper-extremity isometrics did not elicit any oversensing or changes in pacing impedance. However, given the intermittently very high lead impedances, the risk of possible lead fracture or incomplete lead connection in the device header leading to oversensing and inappropriate therapy was thought to be sufficiently high; therefore, ICD therapies were permanently discontinued. Lead revision was considered but deferred, given that the device was placed for primary prevention and that the patient had an LVAD in place, and given her multiple ongoing comorbid conditions.

Discussion

EMI owing to electrosurgery performed below the iliac crest occurs rarely. The ICD-ON registry, which evaluated

331 patients with either ICDs or permanent pacemakers, reported no cases of EMI in 143 pelvic surgeries; however, this study did not involve patients with LVADs.³ In particular, the HeartWare LVAD is an intrapericardial pump composed of 160 g of titanium metal.⁴ It is positioned in the left ventricular apex and consequently can be located very close to the tip of an RV ICD lead, as can be seen on a computed tomography scout film (Figure 3). Additionally, this patient had a fenestrated aortic graft that extended proximally from above the celiac artery to the iliac arteries distally (12 × 28 × 91 mm), composed of polyester on a 316L stainless steel frame, as well as a stent in each renal artery (5 × 22 mm and 6 × 22 mm) also composed of 316L stainless steel (Figure 3). The stents and graft may have conducted electrical signals from the electrosurgery alone or possibly in combination with the LVAD pump. Further confounding a clear explanation for this event are the intermittently elevated ICD lead impedances, suggesting possible lead fracture or incomplete lead connection in the header. Although the patient had a grounding pad on her right leg during the procedure, we hypothesize that the metal of the graft, stents, and LVAD, and/or a malfunctioning ICD lead, acted as conductors for the electrical signals from the electrosurgical unit, allowing those signals to reach the RV lead. In this way, the grafts, stents, LVAD, and/or a malfunctioning ICD lead essentially amplified the electrical signal from the electrosurgical unit for the RV lead. The presence of relatively large-amplitude signals on the RV lead with only very subtle noise seen on the shock EGM suggests that the EMI source could have been proximal to the RV lead tip or that the RV lead was particularly susceptible to EMI. As well, the integrated-bipolar sensing configuration on the ICD lead (vs a true bipolar configuration) may have contributed to the propensity for oversensing. Prior case reports have demonstrated the potential (although rare) for EMI on an ICD owing to an LVAD itself. In this case, the presence of an LVAD, an aortic graft and renal stents, and a malfunctioning ICD lead may have combined to augment a distant

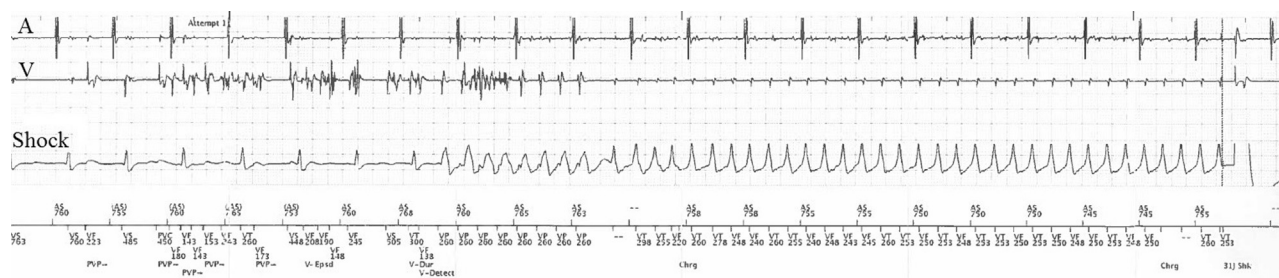


Figure 1 Electrograms (EGMs) showing electromagnetic interference (EMI) detected as ventricular fibrillation (VF) by the implantable cardioverter-defibrillator. A = right atrial lead EGMs, true bipolar sensing; V = right ventricular (RV) lead EGMs, integrated-bipolar sensing from the tip electrode to the RV coil; Shock = “shock” EGM, a far-field signal recorded from the pulse generator to the RV coil. Note the only very subtle noise on the shock EGM, in contrast to the large-amplitude EMI seen on the RV EGM.



Figure 2 Electrograms (EGMs) showing electromagnetic interference (EMI) that was sensed as ventricular tachycardia / ventricular fibrillation but not treated owing to presence of a magnet. A = right atrial lead EGMs, true bipolar sensing; V = right ventricular (RV) lead EGMs, integrated-bipolar sensing from the tip electrode to the RV coil; Shock = “shock” EGM, a far-field signal recorded from the pulse generator to the RV coil. Again, note the only very subtle noise on the shock EGM, in contrast to the large-amplitude EMI seen on the RV EGM.

monopolar electrosurgery signal, resulting in EMI on an ICD lead.^{5–7} While bipolar electrosurgery may have been less likely to result in EMI, the nature of the LEEP necessitates the use of single loop and roller ball electrode, which are only available as monopolar units.⁸ Given that the patient had no prior history of oversensing or ICD therapy until the time that electrosurgery was delivered, the lead malfunction alone was not likely the sole cause of oversensing but may have predisposed the patient to oversensing from external EMI.



Figure 3 Computed tomography scout film demonstrating proximity of the left ventricular assist device (LVAD) to the right ventricular (RV) lead and the location of aortic graft. Note that the caudal end of the aortic graft extends well below the iliac crest. Black arrow indicates the RV lead tip. Note proximity to the LVAD pump. White arrow indicates the top of the aortic graft.

Conclusion

Occurrence of EMI during electrosurgery below the iliac crest is unlikely but clearly can occur, as demonstrated in this patient. The presence of intracorporeal conductors such as metal grafts, stents, and LVADs, along with a malfunctioning ICD lead, may have combined to allow this to occur. Given the very extraordinary combination of clinical factors in this patient, a change in general guidelines for perioperative ICD management is not warranted. However, attention to long-term trends, in addition to same-day measurements during ICD interrogation, may be instructive and may have prompted suspension of therapies prior to surgery in this patient.

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