Turning a blind eye to the far field: Are we burying the evidence? A case of abrupt catastrophic implantable cardioverter defibrillator lead failure causing sudden death

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Introduction

Implantable cardioverter defibrillator (ICD) therapy is commonly used for the prevention of sudden arrhythmic death in high risk populations. A recognized complication of such therapy is lead failure, leading to potential inappropriate detection and delivery of high energy defibrillation shocks. Many modern devices utilize algorithms which can differentiate between lead noise and true arrhythmia, avoiding unnecessary therapies. However, the programming of these algorithms can be the difference between life and death. Below is presented a case of lead failure in which the default programming of the device's algorithms contributed to a catastrophic outcome which was potentially avoidable.

Case report

A 31-year-old male patient was admitted to the hospital with severe heart failure and cardiogenic shock in the setting of amphetamine-induced dilated cardiomyopathy and an ejection fraction (EF) of 5%–10%. After 10 weeks of in-hospital care with the administration of diuretics, inotropes, and intra-aortic balloon counterpulsation and the optimization of medications, his condition stabilized. However, his left ventricular (LV) systolic function remained severely impaired, with an EF of approximately 10%. As a consequence, he received a Protecta VR (Medtronic Corporation, Minneapolis, MN) single-chamber ICD with Sprint Quattro (Medtronic Corporation, Minneapolis, MN) dual-coil lead prior to discharge. At the implantation of the device, the R-wave amplitude was 7.5 mV, the pacing threshold was 0.9 V at 0.4 milliseconds, and the pacing impedance was 784 ohms. The high-voltage lead impedance was 68 ohms through the right ventricular (RV) coil and 61 ohms through the superior vena cava (SVC) coil. Defibrillation testing was not performed, because of the presence of an LV apical thrombus in the preceding month and relative hemodynamic instability at the time of implantation. The device was programmed to detect ventricular fibrillation (VF) at rates >200 beats per minute (bpm), and the therapy to be delivered was a maximum of 6×35-J shocks with antitachycardia pacing (ATP) during charging. Alerts were programmed for RV lead integrity and RV lead noise, for RV pacing lead impedance out of range (<200 or >3000 ohms), and for RV and SVC defibrillation lead impedance out of range (<20 or >200 ohms). 'RV lead noise discrimination' (RVLND) was also programmed 'on' (by default) with an 'RV lead noise timeout' at the default value of 0.75 minute (see the Discussion section for further details).

A significant clinical improvement was noted, and the patient returned to work some months later. At heart failure clinic follow-up, LV EF had improved to 15%–20%, and he was walking up to a mile a day. Medical therapy was continually titrated until he was on optimal doses of beta-blockade, angiotensin-converting enzyme inhibitor, and aldosterone antagonist. The patient missed an ICD follow-up appointment 6 months post implant and was subsequently lost to ICD follow-up.

Three years after initial presentation, the patient died suddenly and unexpectedly, despite feeling well and having no symptoms when he was last seen, 30 minutes prior to his death. Postmortem interrogation of his explanted ICD demonstrated an abrupt failure of his RV pace-sense lead, with an abrupt rise in RV pace-sense lead impedance on the day of the patient's death. The impedance change was associated with detection of noise beginning with short (1 second) episodes of noise just 1 hour 53 minutes before

KEYWORDS Defibrillator; Ventricular fibrillation; ICD therapy; Sudden death; Lead fracture

ABBREVIATIONS **ATP** = antitachycardia pacing; **bpm** = beats per minute; **EF** = ejection fraction; **EGM** = electrogram; **ICD** = implantable cardioverter defibrillator; **LV** = left ventricle; **RV** = right ventricle; **RVLND** = right ventricular lead noise discrimination; **SVC** = superior vena cava; **TWOS** = T-wave oversensing; **VF** = ventricular fibrillation; **VT** = ventricular tachycardia (Heart Rhythm Case Reports 2016;2:6–10)

Dr Tuohy would like to acknowledge The Cormac Trust Sudden Cardiac Death foundation for sponsoring the publication of this article. The authors have no conflicts of interest to declare. **Address reprint requests and correspondence:** Dr Stephen Tuohy, Mater Heart House, 54 Eccles Street, Dublin 7, Republic of Ireland. E-mail address: stephen_tuohy@hotmail.com.

http://dx.doi.org/10.1016/j.hrcr.2015.07.004

KEY TEACHING POINTS

- Inappropriate ICD therapies due to lead noise can be fatal.
- Lead noise-discrimination algorithms have the ability to detect lead noise and withhold high-voltage therapies, but this function is limited by preprogrammed time-outs. These time-outs can be manually extended or disabled by the clinician. Such programming can be the difference between life and death (as in this case).
- Postmortem ICD interrogation should be indicated in cases of sudden unexplained death in an ICD recipient, as catastrophic system failures may be highlighted.

the patient's death. Both lead noise and lead integrity alerts were noted shortly after the episode began. The duration of the noise episodes increased over the intervening period. The device transiently suppressed VF detection by recognizing the high rates as being noise (Figure 1) and due to the default time-out in the RVLND algorithm, VF would have been detected after 45 seconds of persistent noise. However, VF was actually detected after 8 seconds because of an interaction between the T Wave Discrimination algorithm and the RVLND algorithm, resulting in an even shorter suspension of VF detection, to only 8 seconds. The ICD proceeded to deliver a sequence of maximum output 35-J shocks, the third of which induced true VF (Figure 2). Three subsequent shocks failed to terminate the VF (Figure 3), and therapy was automatically discontinued, leaving the patient in VF from which he was not resuscitated.

Discussion

Inappropriate shocks are an unwelcome and potentially life-threatening complication of ICD therapy.[1] Recent advances have dramatically reduced inappropriate shocks due to supraventricular arrhythmias.[2] Inappropriate shocks due to lead fracture or insulation break can be more difficult to prevent, particularly when lead failure is abrupt. The incidence of such events may be underestimated due to a relative paucity of postmortem ICD interrogations, even in cases of unexplained sudden death in ICD recipients.[3] While such sudden deaths are often assumed to be spontaneous arrhythmic deaths, possibly with failure of ICD shocks to terminate episodes, the possibility of episodes being caused by the ICD is rarely considered.

ICD lead fractures may result in failure of detection and therapy delivery as well as lead noise that can result in unnecessary therapy delivery. The failure rate for Sprint Quattro leads has been shown to be 0.43% per year in a multicenter study.[4] Many modern devices have incorporated features to detect noise and avoid inappropriate shocks, but the utility of lead noise-detection algorithms with suppression of tachyarrhythmia detection may be limited by their preprogrammed time-outs.

In this case, the patient had the quadruple misfortune of these events:

1. An abrupt lead fracture with immediate sensing of noise
2. Failure of the RVLND algorithm to prevent detection of VF
3. Induction of VF by one of the resulting shocks
4. Failure to defibrillate by 3 subsequent shocks, despite the fact that charge times, high voltage impedance, and delivered energy were all appropriate or normal

Although the alarms were programmed 'on,' the abruptness of lead failure made it extremely unlikely that the patient would have enough time to seek help in response to a device alarm.

The Medtronic RVLND algorithm differentiates RV lead noise from VT or VF by comparing a far-field electrogram (EGM) signal to near-field sensing.[5] The algorithm instructs

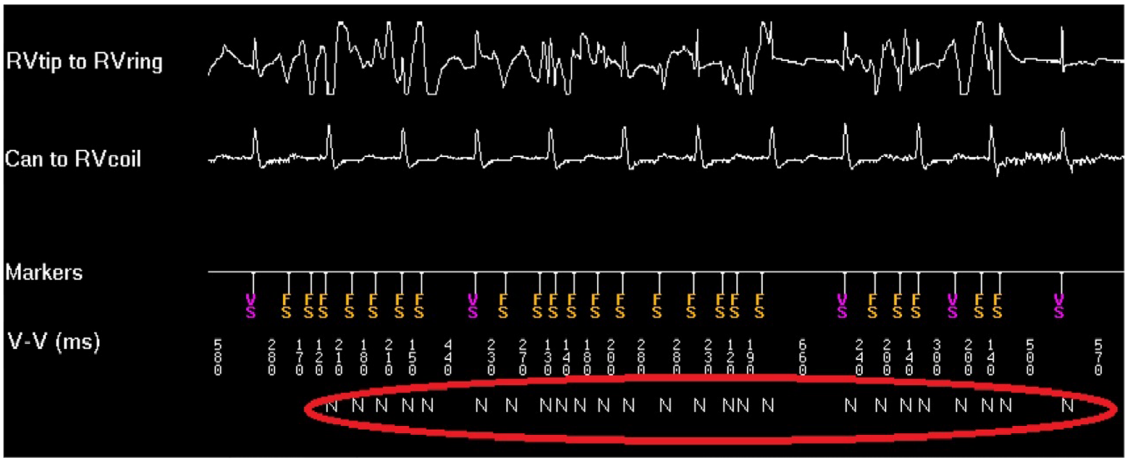

Figure 1 Initial right ventricular lead noise discrimination algorithm (RVLND) inhibiting therapy due to detection of noise (N). The far-field electrogram reveals a stable intrinsic rate.