Case Report of Novel, Automatic Shocking Vector Adjustment Algorithm: A Life-Saving Feature of a Modern Defibrillator

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Abstract

BACKGROUND: Failed delivery of appropriate shocks against fatal dysrhythmias can be the result of low impedance on high-voltage leads. This malfunction might be missed on routine interrogation. We describe the case of a 66-year-old man with a high-voltage lead short circuit who was successfully rescued with the use of an overcurrent detection and automatic shocking vector adjustment algorithm.

CASE REPORT: A 66-year-old man with severe nonischemic cardiomyopathy was admitted after receiving 2 shocks from his cardiac resynchronization therapy cardioverter-defibrillator. Interrogation of his defibrillator confirmed 2 consecutive episodes of ventricular fibrillation. For each episode, the initial shock therapy was aborted due to low impedance (<10 ohms) detected on the default shocking configuration: right ventricle to superior vena cava/implantable cardioverter generator. As a result, the device algorithm excluded the superior vena cava coil and immediately delivered a shock of 40 joules between the right ventricular coil and the cardiac resynchronization therapy cardioverter-defibrillator implantable cardioverter generator. This successfully terminated the ventricular fibrillation. All other lead measurements were normal.

CONCLUSION: High-voltage lead malfunctions can lead to failed therapy of life-threatening dysrhythmias. Malfunctions like a low impedance of high-voltage leads may not be detected on routine interrogation. Fortunately, the overcurrent detection algorithm recognized the low impedance, and another shocking configuration was selected and successfully terminated the ventricular dysrhythmias. With these algorithms, overcurrent detection and automatic shocking vector adjustment, this patient was rescued. We suggest this feature be considered in all modern defibrillators.

Introduction

Failed delivery of appropriate shocks by an implantable defibrillator can be the result of low impedance detected on high-voltage leads. Malfunctions such as these might be missed on routine interrogations, and thus might go unrecognized. Herein we describe a case of the rescue of a patient with a high-voltage lead malfunction with the use of a novel algorithm.

Case Report

The patient was a 66-year-old Black man with a history of severe nonischemic dilated
cardiomyopathy with a severely reduced left ventricular ejection fraction, ventricular fibrillation (VF), and persistent atrial fibrillation. He presented to the emergency room after receiving 2 shocks from his cardiac resynchronization therapy cardioverter-defibrillator (CRT-D), after a witnessed brief loss of consciousness while at home.

Upon interrogation of his Quadra Assura 3365-40C (Abbott, Plymouth, MN, USA) defibrillator there were two confirmed consecutive episodes of VF (Figure 1A). For each episode, the first attempt to terminate the VF with implantable cardioverter-defibrillator (ICD) shock therapy was unsuccessful from the dual-coil high-voltage right ventricular lead, Durata 7120 (Abbott, Plymouth, MN, USA). For each episode, the initial shock therapy was not delivered due to low impedance (<10 ohms) detected on the superior vena cava (SVC) coil (Figure 1B). The default shocking configuration was right ventricle (RV) to SVC/implantable cardioverter generator (CAN). As a result of the low impedance, the device algorithm (overcurrent detection and DynamicTX™ algorithm) excluded the SVC coil and immediately delivered a rescue shock of 40 joules between the RV coil and the CRT-D generator CAN (Figure 1C). This successfully terminated the VF. In addition, with the first shock therapy from the ICD, his persistent atrial fibrillation was converted back to normal sinus rhythm as well. All other lead measurements were within normal limits, with RV pacing impedance of 400 ohms and left ventricle pacing impedance of 940 ohms with pacing vector of M3–M2. The RV pacing threshold was 0.5 V at 0.5 ms, and the left ventricle pacing threshold was 0.5 V at 1.0 ms (M3–M2). RV sensing was found to be greater than 12.0 mV (bipolar). Afterwards, the SVC coil was turned off due to failure to deliver shock therapy from the low impedance.

Because the patient had recurrent VF and subsequently his SVC coil was turned off, it was decided to perform a defibrillation threshold test. VF was successfully induced with high-voltage, high-frequency right ventricular pacing. Successful termination of VF was achieved with a single 30 joule shock, with RV coil to CRT-D CAN shocking vector. A full timeline of the case report can be found in Table S1.

**Discussion**

The annual rate of ICD lead defects reaches ~20% in a 10-year follow-up. In a prior study, 56% of major causes of lead failure were due to lead insulation breaks. Nearly 2/3 of lead defects can be detected on electrical parameters during routine follow-up, but in 1/3 of the cases, the lead defects are found after failed shock therapy. High-voltage lead malfunctions can lead to failed therapy of life-threatening dysrhythmias. In our case, the high-voltage lead malfunction occurred between the RV coil and

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Figure 1: Intracardiac tracings during spontaneous VF episode is shown. (A) VF was successfully detected. (B) The first shock attempt. The exclamation point at the first shock denotes overcurrent detection, which in turn lead to 0.0 joules being delivered. (C) Subsequently, a maximum shock (40.0 joules) using the “RV-CAN” shocking-vector configuration was delivered with successful termination of VF. CAN = implantable cardioverter generator; RV = right ventricle; VF = ventricular fibrillation.
the SVC/CAN because the impedance was below the detection limits (<10 ohms). Fortunately, the overcurrent detection algorithm recognized the low impedance, and the initial shock was not delivered. The automatic shocking vector adjustment algorithm (DynamicTX™) then excluded the SVC coil, and a 40-joules shock therapy was delivered with RV-CAN shocking vector configuration with successful termination of VF (Figure 2).

The novel overcurrent detection algorithm is exclusive to the Ellipse, Fortify Assura, Quadra Assura, and Unify Assura series (Abbott, Plymouth, MN, USA) systems. The overcurrent detection algorithm is designed for a dual-coil system with an active SVC coil (Figure 3). During shock delivery, when low impedance is detected (<10 ohms) in the initial configuration, the overcurrent detection algorithm will abort the shock therapy. This helps prevent damage to the ICD system. After a low impedance is detected in a given shocking vector, the DynamicTX™ algorithm selects an alternative configuration. The vector-switching sequence varies based on the programmed configuration (Figure 3). In our case, the initial configuration (RV to SVC/CAN) failed, therefore it was changed to RV to CAN with delivery of shock therapy and successful termination of VF (Figure 1). At the end of the rescue, the device defaulted back to the initial programmed shocking vector (RV to SVC/CAN). Activation of the Dynamic Tx™ algorithm results in multiple alerts to indicate the presence of a high-voltage lead failure and initiation of an alternative shock configuration. A vibratory alert, if turned on, will also be delivered to the patient.

A case published by Mizobuchi et al. described a patient with low lead impedance detected on SVC coil on a Riata lead (Abbott, Plymouth, MN, USA) while performing a defibrillation threshold test at the time of ICD generator replacement. In their case, a successful rescue shock was delivered from the RV coil to the CAN using the overcurrent detection and DynamicTX™ algorithm. The Food and Drug Administration classified the Riata family of ICD leads as a Class I recall due to inside-out abrasions underneath the shocking coils. Chung et al. described a patient with recurrent VF in the setting of a high-voltage lead short circuit with successful rescue using the DynamicTX™ algorithm. In their case, shock therapy was delivered through an SPL SP02 dual-coil RV ICD lead (Ventritex, Sunnyvale, CA, USA). To our knowledge, the present case is the first to show the efficacy of the DynamicTX™ algorithm in a currently implanted ICD lead. In addition, our case further highlights the importance of overcurrent detection and the success of the DynamicTX™ algorithm in a clinical setting.

**Conclusion**

Without the DynamicTX™ algorithm, patients such as ours might not be rescued. In patients who
present after failed delivery of an appropriate shock for a fatal dysrhythmia, we recommend seeking input from an electrophysiologist to help determine the cause of the failed shock. A defibrillation threshold test should be considered if a high-voltage lead short circuit is suspected. Finally, to provide patients with the utmost protection from fatal dysrhythmias, we suggest algorithms, such as the DynamicTX™ algorithm, be considered in all modern defibrillators.

Supplementary Materials

REFERENCES