Failed defibrillation with unexpected battery depletion by cable externalization of dual-coil defibrillator lead

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Introduction

In 2011, Riata and Riata ST (Abbott Inc, Sylmar, CA) implantable cardiac defibrillator (ICD) leads was placed under a class I US Food and Drug Administration (FDA) recall owing to lead conductor externalization with electrical dysfunction. Mechanisms of ICD lead abrasions are varied and inside-out is one of the mechanisms, which is represented by ethylene tetrafluoroethylene–coated conductor cable abrading through the silicone insulation owing to inside-out erosion, as a result of internal motion in the Riata lead.[1] Another mechanism is outside-in abrasions, namely those caused by contact with another device or anatomic structure.[2] To protect against both types of erosion, the Riata ST Optim™ and Durata™ leads had an outer insulation coating with a copolymer consisting of silicone rubber and polyurethane (Optim), 0.08 mm in thickness, increasing the distance between the cables and the outer lead border by 50%.[3] Although Optim on Durata leads is mechanically stronger, dramatically reducing lead insulation abrasions with these improvements in lead design as compared to silicone outer insulation on Riata leads,[4,5] neither the abrasions nor the severe clinical consequences are completely prevented.[2] We present a patient with Durata lead cable externalization leading to defibrillation failure and battery depletion.

Case report

A 68-year-old female patient with nonischemic cardiomyopathy and sudden cardiac arrest had an ICD with model 7120Q Durata dual-coil defibrillation (Abbott) and model 1999 OptiSense atrial lead (Abbott) implanted in 2011. In 2019 the ICD generator was replaced owing to normal battery depletion with a Vigilant™ EL ICD DR model D233 (Boston Scientific Inc, Marlboro, MA). Both the dual-coil defibrillation lead, a Durata model 7120Q, and the atrial lead, an OptiSense lead model 1999, functioned well and were reused. She developed recurrent episodes of monomorphic ventricular tachycardia (VT) that were not amenable to pharmacological management and, when only partially responsive to an initial VT ablation, underwent a second, Impella-assisted endocardial and epicardial VT ablation. ICD battery status after the second ablation procedure indicated the estimated time remaining to elective replacement interval was 7.5 years. Postoperatively, she developed VT with appropriate ICD shocks. The ICD shocks failed to defibrillate but the patient was resuscitated with external cardioversion (Figure 1). Device interrogation revealed an abrupt decrease in shock impedance and complete battery depletion. However, chest radiograph examination showed no externalization along the lead path to the heart (Figure 2A). Therefore, the patient was taken for surgical assessment of the ICD lead and generator with potential extraction and replacement of the lead and definite replacement of the ICD.

KEY TEACHING POINTS

- One mechanism of lead insulation abrasion of implantable cardioverter-defibrillator (ICD) leads is outside-in abrasions, namely those caused by contact with another device or anatomic structure.
- There is a possibility that failed defibrillation is caused by ICD lead insulation abrasion.
- It is important to keep in mind dressing the lead in the pocket to minimize contact with the pulse generator to avoid future lead-related problems.

Cable externalization and detailed investigation

The left subpectoral pocket was opened and revealed externalization of the cables to the defibrillation coils over a 2- to 3-cm segment that had been resting under the ICD can and a clear breach in the Optim coating and silicone insulation (Figure 3). There were 2 small areas of possible

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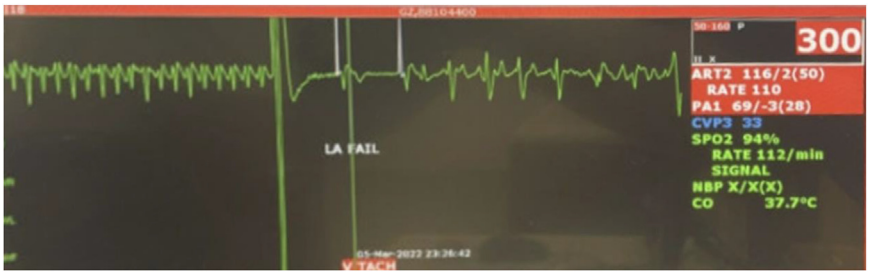

Figure 1 Electrocardiogram revealed that the patient was defibrillated with external cardioversion.

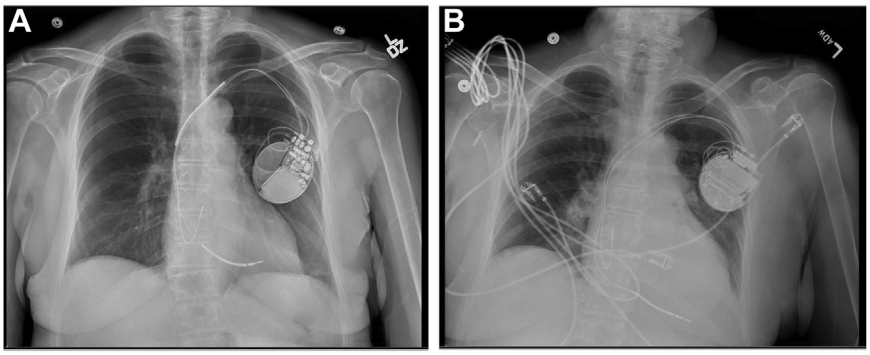

Figure 2 Image of chest radiograph. **A:** Before generator replacement. **B:** After generator replacement.

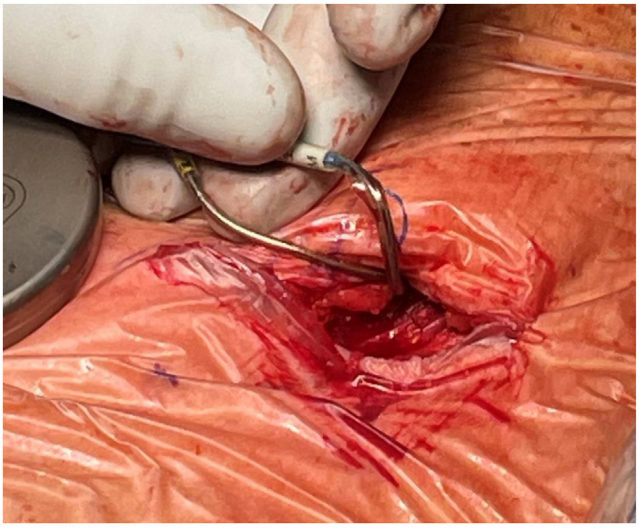

Figure 3 Intraoperative findings revealed externalization of the cables to the defibrillation coils over a 2- to 3-cm segment that had been resting under the implantable cardioverter-defibrillator can and a clear breach in the Optim coating and silicone insulation.

arcing on the can but no discoloration in the subpectoral pocket.

The failed ICD generator (Vigilant EL ICD DR) was returned to Boston Scientific to investigate the root cause of abrupt battery depletion. Detailed analysis revealed that the device battery voltage was not depleted. However, a radiograph of the device revealed that the internal high-voltage fuse was damaged. The damage to the fuse occurred during delivery of the shock and then prevented any subsequent charging of the high-voltage capacitors and delivery of shock therapy. As a result, the subsequent attempted high-voltage charge resulted in the device's declaration of "complete battery depletion" because the capacitors could not successfully complete charging within 30 seconds. The defect in the Optim outer insulation and the pocket externalization, and the mild localized discoloration of the ICD can, together suggest the mechanism of shorted output when the device attempted to deliver a shock through the lead. This evidence indicates that distal coil conductor externalization shorted to the "hot" can electrode.

Device and lead management

The ICD generator was removed, and the ICD lead was extracted using the laser sheath (16F; Spectranetics, Colorado Springs, CO) and Visisheath (Spectranetics) and a new generator (Galant^{TM} DR CDDRA500Q; Abbott) and a new Optisure LDA210Q single-coil defibrillation lead (Abbott) were implanted. The lead was positioned in the pocket in a manner to minimize contact with the pulse generator (Figure 2B).

Discussion

Since insulation abrasion may result in lead failure, abrasion was a problem affecting silicone ICD leads.[6–8] Optim, a copolymer material of silicone rubber and polyurethane, was added as an abrasion-resistant coating to protect the silicone insulation of the main lead body. With these

improvements in lead design, the rate of conductor externalization was significantly decreased from 19%–28% in Riata and Riata ST leads to <1% in Durata and Riata ST Optim leads.[4,5] However, Hauser and colleagues[2] reported 15 cases of Riata ST Optim and 37 cases of Durata leads that had failed owing to abrasions from the US Food and Drug Administration's Manufacturer and User Facility Device Experience database in 2012.

Externalization of the conductors inside the blood pool by inside-out mechanism do not typically result in shorted defibrillation, but if the right ventricular conductor and the SVC conductor or shocking coil are in contact, most likely under the SVC coil, this may result in failed defibrillation and damage to the shocking components of the ICD. In our case, the lead breach occurred under the ICD can in the subpectoral pocket and there were 2 small areas of discoloration on the ICD can. These findings support an outside-in mechanism to the cable of the right ventricular shocking coil, which has the opposite shocking polarity to the "hot can," providing the pathway for the short. This case required complete extraction of the lead and replacement of the ICD. In addition, the way the lead was dressed in the subpectroral pocket in the previous replacement procedure may have caused locally abnormal mechanical stress to the lead, resulting in the lead-to-can abrasion. It is important to keep in mind dressing the lead in the pocket to minimize contact with the pulse generator so as to avoid potential lead-related problems.

Hauser and colleagues[2] reported that the predominant signs of failure for can abrasions were oversensing, inappropriate shocks, and low impedance. There were no Durata lead cases of truncated shock in lead-to-can abrasion. However, in our case, defibrillation could not occur because of damage to the internal high-voltage fuse. Retrospectively, observation revealed that defibrillation lead resistance was decreasing before the short occurred, although full routine lead testing was completely satisfactory with regular device check.

Cause of unexpected battery depletion

In our case, complete battery depletion was falsely declared by the device. However, the internal high-voltage fuse was damaged during attempted delivery of the shock and prevented subsequent charging and delivery of shock therapies; this also resulted in tripping of the replacement time indicator, which declared complete battery depletion. The high-voltage fuse in a defibrillator is a safety switch that breaks if the current flow is too high. If something is not otherwise done to stop electricity from flowing, the high current caused by a lead short circuit could cause significant collateral damage to the device.

Fortunately, external cardioversion restored sinus rhythm for this patient. To the best of our knowledge, this is the first report of cable externalization in a Durata lead resulting in failed defibrillation and apparent unexpected ICD battery depletion.

Conclusion

We describe a case of failed ICD shock owing to unexpected battery depletion of an ICD, which was caused by cable externalization of an Abbott Durata ICD lead, with evidence suggesting outside-in abrasion of the Optim coating. This phenomenon is rare, but an understanding of this potential mechanism may help in identifying or preventing similar issues in other patients.

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