CASE REPORT

Implantable Cardioverter-Defibrillator Shock: Appropriate or Inappropriate?

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A 76-year-old female with a single chamber implantable cardioverter-defibrillator implanted for secondary prevention was referred due to multiple discharges. The device was programmed for ventricular tachycardia (VT) detection at 400 ms, fast VT detection at 280 ms, and ventricular fibrillation detection at 320 ms. Antitachycardia pacing (ATP) during charge was enabled. Interrogation revealed a VT episode with a mean cycle length of 270 ms, which was successfully terminated with ATP during charge. Seconds later, the device delivered a shock. This case illustrates the importance of understanding programming algorithms as part of troubleshooting when facing a scenario of device discharge.

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A 76-year-old female with ischemic cardiomyopathy and a single chamber implantable cardioverter-defibrillator (ICD) (Virtuoso, Medtronic Inc., Minneapolis, MN, USA) implanted for secondary prevention was referred due to multiple ICD discharges. On history, the patient denied any antecedent chest discomfort, palpitation, dyspnea, or presyncope. Functional inquiry and laboratory investigations, including serum potassium, magnesium, and calcium, were unremarkable. The device was initially programmed for ventricular tachycardia (VT) detection at 400 ms (based on interpretation of one of the documented clinical tachycardias), fast ventricular tachycardia (FVT) detection at 280 ms, and ventricular fibrillation (VF) detection at 320 ms. Antitachycardia pacing (ATP) during charge was enabled. Device interrogation revealed a VT episode with a mean cycle length of 270 ms, which was successfully terminated

with ATP during charge (Fig. 1, + 2 ms). Seconds later, the device delivered a 34.6 J shock (Fig. 1, + 10 ms). Why did the device go on to deliver shock following successful termination of VT by ATP?

DISCUSSION

Following detection in the VF zone, Medtronic Virtuoso and subsequent generation Medtronic ICDs start charging the capacitors for delivery of defibrillation therapy. In devices programmed to deliver "ATP during charge," confirmation of persisting VF is performed after charging ends.¹ Before delivering a first shock, the device verifies persistence of VF by monitoring the heart rate.¹ The device employs a sequence of confirmation intervals equal to 60 ms plus the programmed VT zone.¹ Ventricular events occurring within the

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Figure 1. Following a brief run of variable cycle length (CL) ventricular rhythm, a CL of approximately 500 ms ensues. The rate abruptly accelerates into the ventricular fibrillation zone (time -5 s) with a stable CL of 260 ms. Antitachycardia pacing with an eight pulse burst at 240 ms is delivered (time 0 s), which converts the tachycardia (time + 2 s). Eight seconds after successful conversion a 34.6 J shock is delivered (time + 10 s) resulting in nonsustained ventricular tachycardia.

confirmation interval are classified as "arrhythmic" while those falling outside are classified as "normal."¹ For each ventricular event, the preceding five confirmation intervals are reviewed and

classified. If at least four of the preceding events are classified as "normal," delivery of defibrillation therapy is aborted. Failure to fulfill this criterion results in delivery of defibrillation therapy

Figure 2. Following the end of charging the device capacitor (CE, closed arrow) and despite successful termination of tachyarrhythmia, a 34.6 J charge is delivered (CD, open arrow). See text for complete details.

synchronized on the second nonrefractory ventricular event.¹

Here, VT detection is programmed to 400 ms, thus making the confirmation interval 460 ms. Intracardiac electrograms demonstrate a stable monomorphic ventricular rhythm at 260 to 270 ms (Fig. 2). VF is detected (Fig. 2, "FD" on marker channel) and burst ATP (Fig. 2, "TP" on marker channel) is subsequently delivered as a train of eight paced beats at 240 ms. The ATP successfully terminated the ventricular tachyarrhythmia. However, the algorithm confirming persisting VF is not applied until charge end (Fig. 2, "CE" on marker channel), at which point the preceding five ventricular events all occur within the confirmation interval of 460 ms and are thus classified as "arrhythmic." This results in inappropriate charge delivery ("CD" on marker channel) on the second nonrefractory ventricular event (Fig. 2) despite successful ventricular tachyarrhythmia termination with ATP. As this charge was not delivered for its target tachycardia, it is ultimately inappropriate. The patient went on to treatment with increased beta-blocker therapy and initiation of amiodarone. Careful analysis of the previous documented VT episodes revealed the majority of them at the rate of 167 bpm, thus the VT detect zone was reprogrammed to 360 ms.²

CONCLUSION

Implantable cardioverter-defibrillator shocks pose a diagnostic challenge, as differentiation between appropriate and inappropriate shocks is fundamental to subsequent patient management.^{3,4} Following delivery of a therapy, devices employ a confirmation algorithm that is different from the original detection algorithm. An inappropriate

therapy in this setting is almost invariably not due device or lead failure but related to failure to correctly identify return of normal rhythm.⁵ The device "errs" on the side of sensitivity (i.e., not wanting to miss continuing arrhythmia) by employing an algorithm that relies on cycle length as its sole discriminator. Caution should be advised in this particular product since programming the slow VT zone has direct implications for the confirmation algorithm.⁶ The preceding case illustrates the importance of understanding device programming algorithms as part of ICD trouble-shooting when facing a scenario of device discharge.

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