A 49-year-old man consulted our department 3 months after having several implantable cardioverter-defibrillator (ICD) shocks with subsequent syncpe. A CRT-D device (Boston Scientific, Cognis 100-D) and a single-element subcutaneous array (Medtronic, model 6996 SQ) had been implanted 2 years previously for primary prevention of sudden cardiac death caused by symptomatic (New York Heart Association class III) nonischemic dilated cardiomyopathy with severely impaired left ventricular function (left ventricular ejection fraction, 10%) and a left bundle-branch block (QRS width, 176 ms). ICD interrogation revealed a prolonged episode of tachyarrhythmia starting at the time of implantation of the CRT-D device, a single-element subcutaneous array had been implanted in our patient to obtain an acceptable DFT. VF induced by T-wave shock had been successfully terminated twice at 21-J with a reversed wave form polarity (ie, RV coil=anode, can+SQ array=cathode). The device was programmed to deliver 8 shocks at maximal energy (41 J) including a single ATP train during charging. Nevertheless, 7 consecutive maximum output shocks (41 J) were required to eventually terminate the presenting Ventricular Arrhythmia episode in our patient. On admission, interrogation of the device showed stable lead and device parameters within normal limits. There was no undersensing, and ICD charging times ranged from 7.2 to 8.6 seconds. Reversible causes of transient DFT changes such as hyperkalemia or ischemia were clinically unlikely. There were no signs or symptoms indicating a progression of the underlying cardiomyopathy. The patient was on standard heart failure medication (enalapril, carvedilol, torsemide, spironolactone) and denied the intake of amiodarone or any other specific antiarrhythmic drug. A circadian variation has been ascribed to DFT with a morning peak in DFT associated with a morning peak in DFT failure in a patient with a prior history of ventricular fibrillation (VF) caused by the first 41-J shock. However, it can be demonstrated with bayesian analysis that a high proportion of failed DFT tests with modern ICDs will be false-negative results possibly resulting in unnecessary revision.1 Nevertheless, implant testing occasionally will correctly identify a system failure and indicate a necessary system revision that saves a patient’s life—a circumstance that has been described as “the implantor’s dilemma.”1

Because of a high DFT (>41 J in any shock vector configuration) at the time of implantation of the CRT-D device, a prolonged episode of tachyarrhythmia started at the time of implantation of the CRT-D device, a single-element subcutaneous array had been implanted in our patient. ICD interrogation revealed a prolonged episode of tachyarrhythmia starting with a fast monomorphic ventricular tachycardia (VT cycle length, 230 ms). Antitachycardia pacing (ATP) during charging led to discrete VT acceleration, followed by degeneration into ventricular fibrillation (VF) caused by the first 41-J shock. Another 5 ineffective ICD shocks were delivered. Eventually, the seventh shock was able to terminate VF (Figure 1). Chest radiographic examination revealed a dislodged SQ array requiring surgical revision (Figure 2). After positioning of a new SQ array, the intraoperative defibrillation threshold (DFT) was determined at 21 J. No perioperative complications occurred, and the patient could be discharged home after recovery. On follow-up 6 weeks later, the patient remained in stable condition with no arrhythmia recurrence.

Discussion

Our current understanding conceives ventricular defibrillation as a probabilistic event that can be described by a sigmoidal probability-of-success curve.1 Consequently, a true DFT above which defibrillation will always succeed cannot be defined. Instead, the goal of DFT testing is to determine an energy level that has a reasonable likelihood to terminate future ventricular tachyarrhythmias. An empirically established 10-J safety margin is then added to the DFT, expecting it to compensate for the probabilistic nature of defibrillation.

The value of intraoperative DFT testing has been the topic of much debate. No standardized protocol exists, and clinical practice varies with each institution. With modern left pectoral high-output ICDs, the probability of successful DFT testing with a 10-J safety margin is estimated at 95%.

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cranial migration of the SQ array, a rare but known complication that from a mechanistic point of view is likely to increase DFT.1
Nevertheless, the case is curious in that all 6 successive ICD shocks delivered were ineffective, but the seventh discharge in fact terminated VF. Duration of VT/VF > 15 seconds is believed to increase DFT.1 As the VF episode persisted (total of 2 minutes, 7 seconds), the patient was likely to have developed acidosis, which in turn is known to contribute to DFT rise.1 Interestingly, the body position presents another influential factor: DFTs are higher in the upright than the supine position.4 One might speculate the syncope after the first ICD shocks could have contributed to the finally successful conversion. Taken together, the present case report emphasizes all the factors potentially altering defibrillation outcome, suggesting that annual chest radiographs and/or regular DFT testing may be reasonable in patients with SQ arrays.

Luckily, our patient had received an ICD device providing up to 8 consecutive shocks for ventricular tachyarrhythmias, presuming the seventh try’s a charm.

Disclosures

None.

References


Keywords: cardiac resynchronization therapy ■ ventricular fibrillation ■ defibrillation threshold ■ subcutaneous array

Figure 1. Ventricular tachycardia episode storage from a CRT-D device (Boston Scientific, Cognis 100-D) is shown. Shown are the atrial (A), right ventricular (RV), and shock (SCHOCK) electrograms with the corresponding annotated markers; [AS], atrial detection during blanking; RVS/LVS, RV/LV detection; AP, atrial stimulation; RVP/LVP, RV/LV stimulation; PVP, PVARP after VES; V->A, ventricular rate higher than atrial rate; VF, VF zone detection; Suddn, sudden onset; Unstb, unstable; Chrg, charging; Shk, shock; and Versuch, therapy attempt. The episode starts with a fast monomorphic VT (cycle length, 230 ms). ATP during charging (QUICK CONVERT ATP, 8 pacing pulses at 88% coupling interval) is not effective. Subsequent to ICD shock therapy, VT degenerates into VF. A total of 7 successive ICD shocks are delivered, with only the last one successfully terminating VF followed by postshock pacing mode.
Figure 2. A, Posteroanterior view of chest radiography shows a dislodged single-element subcutaneous array (Medtronic, model 6996 SQ) in close proximity to the active can of the device (arrowhead). CRT-D leads are appropriately located. Macroscopically, no insulation defect can be visualized. B, Lateral view of chest radiography demonstrating the cranially migrated single-element subcutaneous array (Medtronic, model 6996 SQ). The atrial lead is located in the right atrium; the left ventricular lead lies along the coronary sinus.
Seventh Try's a Charm: Ventricular Fibrillation Terminated by the Seventh Shock
Jin Li, Edgar Zitron, Hugo A. Katus and Ruediger Becker

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