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A Fully Malfunctioning Implantable Cardioverter-Defibrillator Device

Tamamen Arızalı İmplante Edilebilir Kardiyoverter-Defibrilatör Cihazı

CASE IMAGE
OLGU GÖRÜNTÜSÜ

A 50-year-old male with 2 mechanical heart valves and cardiomyopathy underwent a single electrode dual-coil (Durata™, St. Jude Medical) implantable cardi overter-defibrillator (ICD) (Current™+VR, St. Jude Medical) implantation in 2014. Initially measured values were R-wave sensing amplitude of 12 mV, bipolar capture threshold of 0.5 V, and bipolar and high-voltage (HV) lead impedances of 440 Ω and 65 Ω, respectively. No device interrogation although the device activated the patient's notifier many times was performed due to the patient's non-compliance until the worsening of heart failure and hospitalization. Device interrogation showed too high ventricular lead impedance (>3000 Ω), too low high-voltage lead impedance (<10 Ω), inconvenient sensing values with no activity in the ventricular sense amplitude channel (the only channel configured) mostly, and no pacing capture although the device showed continuous ventricular pseudo-pacing in the ventricular sense amplitude and marker channels at the predefined back-up level of 40 bpm (Figure 1A). Numerous event records demonstrated noises with variable sensing signals including very high counts and silences in the ventricular sensing amplitude channel, and fibrillation markers in the marker channel mostly ended spontaneously, sometimes resulting in capacitor charging with premature discharging (Figure 1B). Alerts box included 255 possible HV circuit damage detections, no successful charge since the first detection, aborted shocks due to a possible HV lead issue, ventricular lead impedance > upper limit, HV lead impedance < lower limit, and delivered patient notifiers. The posteroanterior chest x-ray showed the fractured lead in the pectoral region. Before replacing both the electrode and the generator, fluoroscopy of the entire system demonstrated a fractured segment in detail without an additional gross abnormality (Figure 1C and video). After discussion with the patient about the risks and benefits of the lead extraction and retention of the lead, adding a new ICD lead (Sprint Quattro Secure MRI™ SureScan™, Medtronic) without removal of the existing failed lead and replacement of the ICD generator with a new one (Protecta™ VR, Medtronic) were decided and performed (Figure 2). In addition, the manufacturer's advice was along with this direction because fractured lead could affect the proper functioning of the device circuits and alert notifications included possible HV circuit damage which could result in no shock delivery during a ventricular arrhythmia. The explanted ICD device was also sent to the manufacturer for a detailed analysis of the problem and, the manufacturer reported the same findings that the HV circuit was damaged from an unacceptable high current drain. Some devices from the same manufacturer but not the current device have a special feature called DynamicTx™ over-current detection algorithm which automatically changes the HV voltage delivery configuration when an abnormally high current is detected in the programmed configuration. Therefore, no device replacement is necessary when a failure issue such as an electrical short circuit is detected in the venous coil.

There are 2 important chances for the current case. First, fortunately no life-threatening ventricular arrhythmia occurred during the time the device was not functioning. Second, no inappropriate shock for possible pectoral myopotentials was delivered due to a damaged HV circuit by the device. The device (and lead) was damaged, so every time the device tried to charge found that there was internal circuit damage and the shock was aborted. Before HV therapy, the system was tested internally. First,

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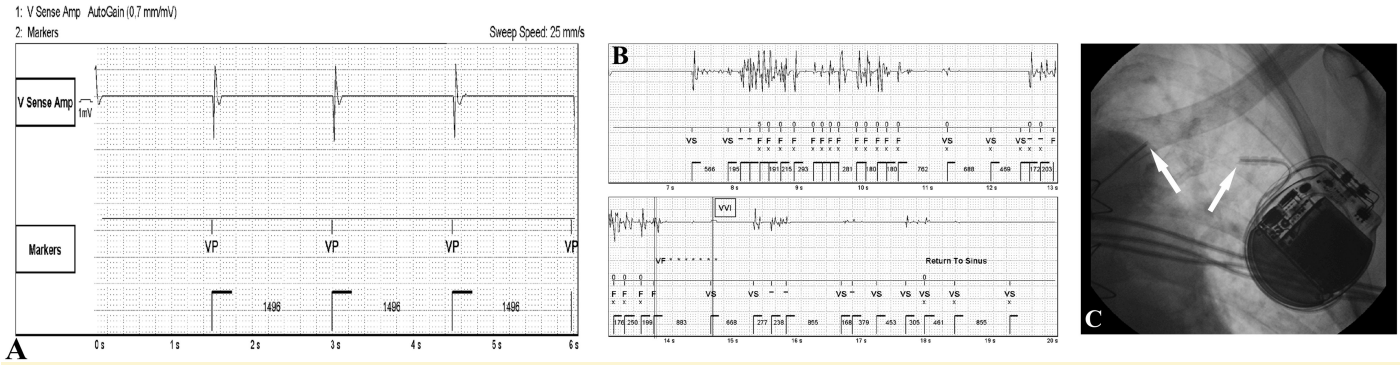

Figure 1. Inappropriate ventricular pacing (VP) attempts are seen on "ventricular sense amplitude" and "markers" channels at a programmed rate of 40 bpm (A). Inappropriate occasional ventricular sense events (VS), frequent high frequency counts as fibrillation (F), and capacitor charging for (VF) detection (sequential asterisks) with premature decharging and no shock delivery (B). A completely fractured electrode segment (arrows) is seen on fluoroscopy (C).

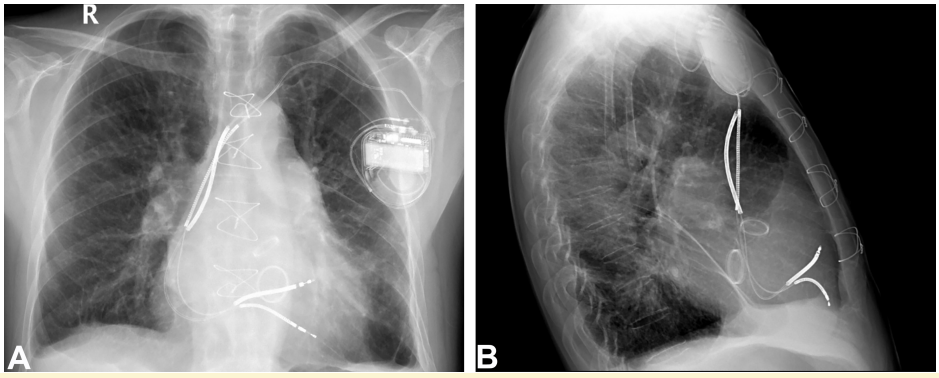

Figure 2. Chest x-ray images showing the new implantable cardioverter-defibrillator system with preexisting fractured lead in situ in the posteroanterior (A) and lateral (B) views.

the device was checked by performing an internal shock circuitry test and then testing the lead (over the current detection test). Both seem to have failed in the case, and no shock was delivered. As known, the HV circuit converts the low-voltage drain from the ICD battery to the HV output using a direct current-to-direct current transformer that makes a huge voltage step-up. Generated HV output charges the capacitor for shock delivery. In normal conditions, the HV circuit tolerates both high voltages and high currents using switchers/transistors up to a level. For example, an 830 V (36 J) voltage creates about 12 A current in a 70 Ω defibrillator conductor. As in the current case, if the same voltage (830 V) is delivered into a pathway with such a low resistance (<10 Ω), a huge peak current of >80 A drains into the circuit, which causes catastrophic damage to the HV circuit.

Leads are the weakest hardware in an ICD system.[1] Both macro and micro insulation/conductor breaches and fractures might be detected, and these lead failures can be asymptomatic or can be a reason for mortality because of an undelivered shock to the patient during a ventricular arrhythmia. Implantation techniques such as subclavian puncture, excessive force during sleeve ligation, extreme twisting, lead design, and patient-related factors such as weightlifting, pocket manipulations, and trauma are possible mechanisms of lead failure.[2,3] Also, younger patients (<50 years) and patients with smaller diameter ICD leads have been shown to be at increased risk for lead fracture, particularly around the time of intense physical activity.[2,4] The latter 2 risk factors could contribute to the lead fracture in our case. Lead failure might also cause ICD device failure, as in the current case. Proper implantation methods such as axillary vein puncture and optimal placing of the hardware in the pocket, use of the newest generation lead with a good long-life performance, and informing the patient about how he/she protects the pocket region are the main protective measures. Also, short- and long-term management of a failed lead includes reprogramming if possible, changing the configuration, inserting a new lead with or without extraction of the existing lead, and device replacement if it also failed.[5]

Informed Consent: Informed consent was obtained from the patient for the publication of the case image and the accompanying images.

Conflict of Interests: The authors declare that there is no conflict of interest.

Video: Corresponding video of panel C.

References

1. Maisel WH. Transvenous implantable cardioverter-defibrillator leads: the weakest link. *Circulation*. 2007;115(19):2461-2463. [CrossRef]

2. Borleffs CJ, van Erven L, van Bommel RJ, et al. Risk of failure of transvenous implantable cardioverter-defibrillator leads. *Circ Arrhythm Electrophysiol*. 2009;2(4):411-416. [CrossRef]
3. Kleemann T, Becker T, Doenges K, et al. Annual rate of transvenous defibrillation lead defects in implantable cardioverter-defibrillators over a period of >10 years. *Circulation*. 2007;115(19):2474-2480. [CrossRef]
4. Morrison TB, Rea RF, Hodge DO, et al. Risk factors for implantable defibrillator lead fracture in a recalled and a nonrecalled lead. *J Cardiovasc Electrophysiol*. 2010;21(6):671-677. [CrossRef]
5. Kalahasty G, Ellenbogen KA. Management of the patient with implantable cardioverter-defibrillator lead failure. *Circulation*. 2011;123(12):1352-1354. [CrossRef]