An unusual cause for inappropriate defibrillator shock

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1. Case

A 50-year-old lady with dilated cardiomyopathy and scar VT underwent single chamber implantable cardioverter-defibrillator (ICD, Medtronic Ltd, Evera XT VR, DVBB2D1) implantation 2 months back. A Sprint Quattro secure 6947 DF1 dual coil lead was placed at the RV apex. She presented to us with an ICD shock while having breakfast. There was no history of preceding palpitation or chest pain. The device interrogation showed a 36 J shock in the VF zone (Fig. 1A). However, the stored electrograms (EGM) revealed distinct QRS complexes in the far-field EGM; hence, suggesting the shock is related to oversensing. Fig. 1B shows 2 panels of another recent episode. There was an aborted therapy as there was intermittent resolution of the oversensing. The lead impedance was found to be normal but the threshold was high. Is it possible to predict the reason for the oversensing from the EGM and how to troubleshoot?

2. Commentary

The possible options are:

1. Electromagnetic interference (EMI)
2. Lead noise (lead fracture/insulation failure)
3. Loose set screw
4. Diaphragmatic myopotential.
5. Pectoral myopotential.

Few key observations in the tracings are:

1. There is more noise in the near field (NF, tip to ring) than far field (FF, Can to coil). In fact, there is hardly any QRS/clear electrogram in NF in spite of 10 times more auto-magnification of NF electrogram [0.1 vs 1 mV scale].
2. The oversensing in the marker channel is intermittent although there is background noise throughout. As the intensity of background noise varies, the oversensing varies simultaneously, making it intermittent in the marker channels.
3. The characteristic of the noise (which is clearer in panel 1B) is like myopotential (high frequency, low amplitude) as compared...
to make and break signals of lead fracture (high frequency and high amplitude).

Based on the first point, EMI becomes unlikely in which both channels have nearly equal noise in a majority of cases [1]. Noises related to lead integrity issues have highly varying amplitude unlike a uniform noise like the index case. The lead impedance was within normal range. Loose set screws can have similar EGM quality and commonly present in the perioperative period. Moreover, abnormal impedance is often detected in set screw related oversensing [2]. In the index case, prominent noise in the NF channel makes an issue related to lead tip much more likely [1].

Myopotential appears to be the most likely possibility as per the high frequency, low amplitude uniform nature of the noise. Both pectoral and diaphragmatic myopotentials (DMP) are non-cyclical but can have variation of the noise related to arm movement/respiration respectively. However, pectoral myopotential tends to have more noise in FF/leadless EGM as the IPG (Can) is nearby [1,3]. As ICDs do not use FF signals as default sensing channel, pectoral myopotentials do not lead to oversensing (unless the sensing polarity is manually changed) [2]. In the index case, NF predominant noise indicates oversensing related DMP. Real time EGM during deep inspiration also confirmed the same. Arm movement, isometric handgrip or posture change did not reveal any increment in noise.

When oversensing is suspected due to DMP, lead perforation shall be the prime suspect. This can be confirmed by signs of pericarditis or pericardial effusion [1]. With intact lead, DMP

Fig. 1A. Stored electrograms of the treated episode in the VF zone. It shows oversensing of noise dissociated from the native QRS.

Fig. 1B. The lower 2 panels are continuous tracings from another recent episode where the therapy got aborted as the noise amplitude became below the RV lead sensitivity. The lowest panel also shows undersensing and inadvertent RV pacing after the 2nd QRS complex. The LOC could be true or functional.
oversensing is highly unlikely with true bipolar sensing in dedicated bipolar leads [4]. It can however take place when sensitivity is maximum e.g. after long diastolic intervals or ventricular paced events, and often ends with a sensed R wave, which reduces sensitivity abruptly [5]. Thus, it commonly occurs in pacing dependent ICD patients, in whom inhibition of pacing maintains high ventricular sensitivity, resulting in persistent oversensing as well as inappropriate detection of VF [1].

Our case had dedicated bipolar lead without pacing requirement, hence, perforation was suspected upfront. However, echocardiography did not show any pericardial effusion. The lead could be traced only up to the apex. But the device parameters were grossly abnormal. R wave amplitude (sensing) was < 1mV and loss of capture (LOC) was evident even at highest output. In fact, the lowermost panel in Fig. 1 shows undersensing along with LOC (true/functional) in the Vp beat. Interestingly, pacing and shocking impedance trends were all within normal range. Finally, chest X ray (CXR) and fluoroscopy confirmed a lead perforation as the lead was noted outside the cardiac silhouette almost reaching the inner chest wall (Fig. 2).

Skeletal myopotentials including DMP have predominant frequencies in the range of 75 Hz, but they have a proportion of frequency content up to 100–200 Hz and some as low as 20 Hz. In ICDs, low-pass filters in the range of 40–80 Hz can attenuate high-frequency components, but at times sufficient high-frequency signals can still bypass these filters to give myopotential electrograms a distinctive appearance like our case [1]. Newer ICDs have in-built algorithms to reliably suspect and withhold therapies related to noise. In fact, the index patient had several more episodes of oversensing where therapy was aptly withheld due to the noise detection algorithm.

After explaining the scenario, she was scheduled for lead extraction in a hybrid operation theater (OT). In the OT under general anesthesia, the lead was unscrewed and pulled out. No evidence of pericardial effusion/tamponade was noted on intra-operative trans-transesophageal echocardiography (TEE). After waiting for 10 min, a new single coil ICD lead was positioned into lower-mid septum on the same sitting. Perioperative period was uneventful. To summarize, this unique case describes one of the rarer causes of inappropriate ICD discharges. This case also highlights the need for careful implantation of ICD leads which are heavier and stiffer leading to more preponderance for perforation than the lighter pacing leads.

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Data availability statement

All raw data and recording during the case are available for review.

Consent

Consent has been taken from patient.

Declaration of competing interest

This is to declare that all of us are authors of the following manuscript titled ‘An unusual case for inappropriate defibrillator shock’ and we have no conflict of interest.

References

[1] Swerdlow CD, Asirvatham SJ, Ellenbogen KA, Friedman PA. Troubleshooting implanted cardioverter defibrillator sensing problems I. Circ Arrhythm Electrophysiol 2014 Dec;7(6):1237–61. https://doi.org/10.1161/CIRCEP.114.002344. PMID: 25516582.
[2] Bera D, Saggu DK, Chandra Murthy GS, Yalagudri S, Sridevi C, Narasimhan C. Inappropriate defibrillator shock due to oversensing. What is the mechanism?. Jan-Feb Indian Pacing Electrophysiol J 2021;21(1):54–8. https://doi.org/10.1016/j.ipej.2020.09.005. Epub 2020 Sep 28. PMID: 32998013; PMCID: PMC7854366.
[3] Wiegand UK, Wilke I, Bonnemeier H, Eberhardt F, Bode F. Inadequate ICD discharges due to diaphragmatic electromyopotential oversensing as the first sign of right ventricular lead perforation. Pacing Clin Electrophysiol 2006 Oct;29(10):1176–8. https://doi.org/10.1111/j.1540-8159.2006.00511.x. PMID: 17038150.
[4] Kowalski M, Ellenbogen KA, Wood MA, Friedman PL. Implantable cardiac defibrillator lead failure or myopotential oversensing? An approach to the diagnosis of noise on lead electrograms. Europace 2008;10:914–7.
[5] Santos KR, Adragão F, Cavaco D, Morgado FB, Candeias R, Lima S, Silva JA. Diaphragmatic myopotential oversensing in pacemaker-dependent patients with CRT-D devices. Europace 2008 Dec;10(12):1381–6.