An unusual cause for inappropriate defibrillator shock.

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Abstract

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 RV apex. Now, she presents with an episode of ICD shock while having breakfast. The device interrogation shows a 36 J shock in VF zone (Fig 1A). However, the stored electrograms (EGM) reveal 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. Fortunately, there was aborted therapy as there was intermittent resolution of the oversensing. The lead impedance was normal but threshold was high. Is it possible to predict the reason for the oversensing from the EGM and how to troubleshoot?

Title Page

Title: An unusual cause for inappropriate defibrillator shock.

Short title: Late ICD lead perforation leading to defibrillator shock.

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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 RV apex. Now, she presents with an episode of ICD shock while having breakfast. The device interrogation shows a 36 J shock in VF zone (Fig 1A). However, the stored electrograms (EGM) reveal 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. Fortunately, there was aborted therapy as there was intermittent resolution of the oversensing. The lead impedance was normal but threshold was high. Is it possible to predict the reason for the oversensing from the EGM and how to troubleshoot?

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 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 screw can have similar EGM quality and commonly present in 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.

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 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 upto 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 to 200 Hz and some as low as 20 Hz. In ICDs, low-pass filters in the range of 40 to 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 a several more episodes of oversensing where therapy was aptly withheld due to noise detection algorithm.

After explaining the scenario to the patient's relatives, 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. Luckily no evidence of pericardial effusion/ tamponade was noted on intraoperative trans-esophageal 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 summarise, this unique case describes one of the rarer causes of inappropriate ICD discharges. This case also highlights the need for careful implantation ICD leads which being heavier and stiffer, have more preponderance for perforation then softer pacing leads.

Fig legends

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 2^{nd} QRS complex. The LOC could be true or functional.

Fig 2: Preoperative chest X ray showing lead beyond cardiac silhouette suggestive of perforation

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