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Case Report

Inappropriate shock for myopotential over-sensing in a patient with subcutaneous ICD

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ABSTRACT

Inappropriate ICD shocks are common adverse events; they are mainly due to supraventricular arrhythmias and secondly are related to noise, undersensing, oversensing, device malfunctions. We present a case of inappropriate device therapy due to myopotential oversensing in a patient with a subcutaneous ICD (s-ICD). A 58 years old male with an s-ICD during the device interrogation showed a previous episode of suspected sustained ventricular tachycardia at 210 bpm, which was effectively treated with ICD shock. The patient experienced the electrical shock while holding a big gas-cylinder in his arms. The EGM analysis revealed many irregular ventricular signals of low amplitude lasting for 24 s and interrupted by the shock. The device showed no malfunctions. This is the first case report of inappropriate S-ICD shock related to myopotential over-sensing. By recording intracardiac EGM, we demonstrated that the noise was created by the activity of the pectorals muscles.

1. Introduction

Inappropriate ICD activation related to rhythm other than ventricular fibrillation (VF) or sustained ventricular tachycardia (VT) is one of the most common adverse events associated with implantable cardioverter defibrillators (ICDs). Approximately 12–29% of patients with ICDs receive inappropriate shocks,[1–4] accounting for up to 50% of the total complications. Inappropriate shocks are primarily due to tachyarrhythmia – up to 90% of inappropriate shocks[2] – and secondly are due to noise, under-sensing, over-sensing, device malfunction and far-field R wave over-sensing.[2,5,6] In patients with ICDs, the most common tachyarrhythmia related to inappropriate shocks is atrial fibrillation,[1,3] followed by supraventricular tachycardia, sinus tachycardia, and non-sustained VT.[1,3] This is the report of a case of inappropriate device therapy due to myopotential over-sensing in a patient with subcutaneous ICD (S-ICD). To our knowledge it is the first report of myopotential over-sensing in a patient with an S-ICD: there is no other similar case in literature. S-ICD will probably be a relatively common device in future, therefore cardiologists should have an adequate knowledge of technical and clinical issue related to this type of device.

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2. Case report

This is the story of A.M., male, 58 years old, ischemic dilated cardiomyopathy, recently implanted with an S-ICD, after a long medical history of ventricular tachyarrhythmias. He has history of a large anterior wall myocardial infarction 15 years back, when angiogram showed a chronic inter-ventricular anterior coronary branch obstruction and echocardiography revealed a dilated cardiomyopathy with left ventricular ejection fraction (EF) equal to 25%. A single chamber ICD was implanted. Afterwards, despite adequate antiarrhythmic medical therapy, several sustained slow VT occurred and were effectively interrupted by ICD shock. So we decided to ablate the slow VT and during the ICD replacement we performed an upgrade to cardiac resynchronization, firstly to reduce the progression of heart failure and secondly to treat VT with a more effective biventricular ATP. The latter strategy has been recently validated by ADVANCE-CRT-D trial.[7] Months ago the patient showed fever with ICD dislodgement and decubitus. The diagnosis of ICD-related epidermidis-MRSA endocarditis was confirmed by laboratory cultures and vegetations at transesophageal echocardiography. After 3 weeks of antibiotic therapy the device was explanted and because of the high risk of sudden death we decided to implant an S-ICD (Boston Scientific, 1010 SQ-RX). Before the implant a surface EKG screening for S-ICD was performed and the patient resulted eligible with 2/3 EKG leads. During the routine device control, S-ICD interrogation showed one episode of suspected sustained VT at 210 bpm effectively treated with ICD shock twenty days before. We asked him if he had experienced the shock, and he actually remembered a sudden "electrical shaking" while he was setting down a gas-cylinder, with brief chest pain which obliged him to rest on the sofa. The EGM analysis revealed many irregular ventricular signals of low amplitude lasting 24 s interrupted by the shock of device; the shock was followed by sinus rhythm (Fig. 1A). The low amplitude irregular signals looked like VF or, alternatively, noise. All electrical parameters of s-ICD were regular, sensing vector was adequate, the lead system was intact and electrode impedance was stable at 250 Ω (at implant 200 Ω). During device control, we confirmed the device therapy settings (the upper-rate cut-off for the conditional shock zone was confirmed between 180 and 209 bpm, with the shock delivery zone upper than 210 bpm).

We asked the patient to accurately describe what he was doing before feeling the "electrical shock". He was bending forward, holding with hands, arms and knees a heavy gas-cylinder and trying to lift it up for his fish-aquarium. So during the visit we reproduced the myopotential over-sensing asking the patient to repeat the effort holding a gas-cylinder. We changed the sensitivity of the device through amplifying the gain and then we changed the sensing vector (passing from the primary to secondary sensing vector) to avoid inappropriate shocks and so we resolved the problem.

3. Discussion

The EFFORTLESS S-ICD registry[8] collected the data of 472 patients with s-ICD and reported a relatively low incidence of inappropriate therapy (rating of 7%), mostly due to inappropriate cardiac sensing (5.3%) and supraventricular tachycardia (1.3%), with a very low incidence of non-cardiac inappropriate sensing (0.009%). The inappropriate shock rates (7%) in patients with S-ICD are comparable with the standard trans-venous ICD studies, registries and trials which range from 4 to 29%.[1–4,8–10] While in trans-venous ICDs inappropriate therapies are primarily due to supraventricular arrhythmias, in S-ICD the main cause of inappropriate shocks is T-wave oversensing.

Several discrimination algorithms have been introduced to traditional ICD without eliminating the problem of inappropriate shocks, with still a relatively high incidence despite detection algorithms (rhythm onset, interval stability, electrogram morphology, and if an atrial lead is present also the analysis of atrial rates and the relationship between atrial and ventricular electrograms). The S-ICD has several options for management of inappropriate shocks without the need for an invasive procedure including reprogramming of the sensing vector, and in S-ICD it is possible to choose from 3 different sensing vectors.

During the visit, when the patient explained what he was doing, we carefully looked at the EGM and we finally realized what had really happened. While he was handling the heavy cylinder, the device delivered inappropriate shock because it recorded signal over-sensing due to noise of low amplitude signals related to myopotential. During the visit we asked the patient to reproduce the up-lifting of an oxygen heavy gas cylinder, and EGM showed altered ventricular signals, but this time ICD correctly classified them as "noise" (Fig. 1B), perhaps because of the minor effort in handling the cylinder. By recording intracardiac electrocardiogram we demonstrated that the noise was created by the activity of the pectoral muscle, because the small amplitude of the muscular potentials was detected by the ICD device as VF.

The problem of over-sensing related to myopotential was solved by setting a new configuration in device sensitivity. We changed the sensitivity of S-ICD through amplifying the gain ("2× gain" selection amplifies the signal twice), and then we changed the sensing vector passing from "secondary" to "primary" sensing vector in order to achieve a better sensitivity and to avoid inappropriate shocks. Secondary sensing vector is the vector from the distal sensing electrode ring on the subcutaneous electrode to the surface of the active SQ-Rx device, while primary sensing vector is the vector from the proximal electrode ring on the subcutaneous electrode to the surface of the active SQ-RX device. With this new configuration, while the patient held the heavy cylinder tight, no noise was detected but only a regular sinus rhythm (Fig. 2). This change in the settings of device has finally solved the problem.

In different studies we observed that the eligibility of the patients for s-ICD changed if 1 or more leads were considered suitable in surface EKG screening template. With only 1/3 EKG surface lead, eligibility was reached in 96% of patients, but considering 2/3 EKG surface leads, eligibility decreased to 85% and, considering all the leads, eligibility was 37%.[11] This is a key point, in fact in those patients with one inappropriate shock for over/under-sensing, it is very important to have a second or a third sensing source. Moreover we know that EKG has some modifications related

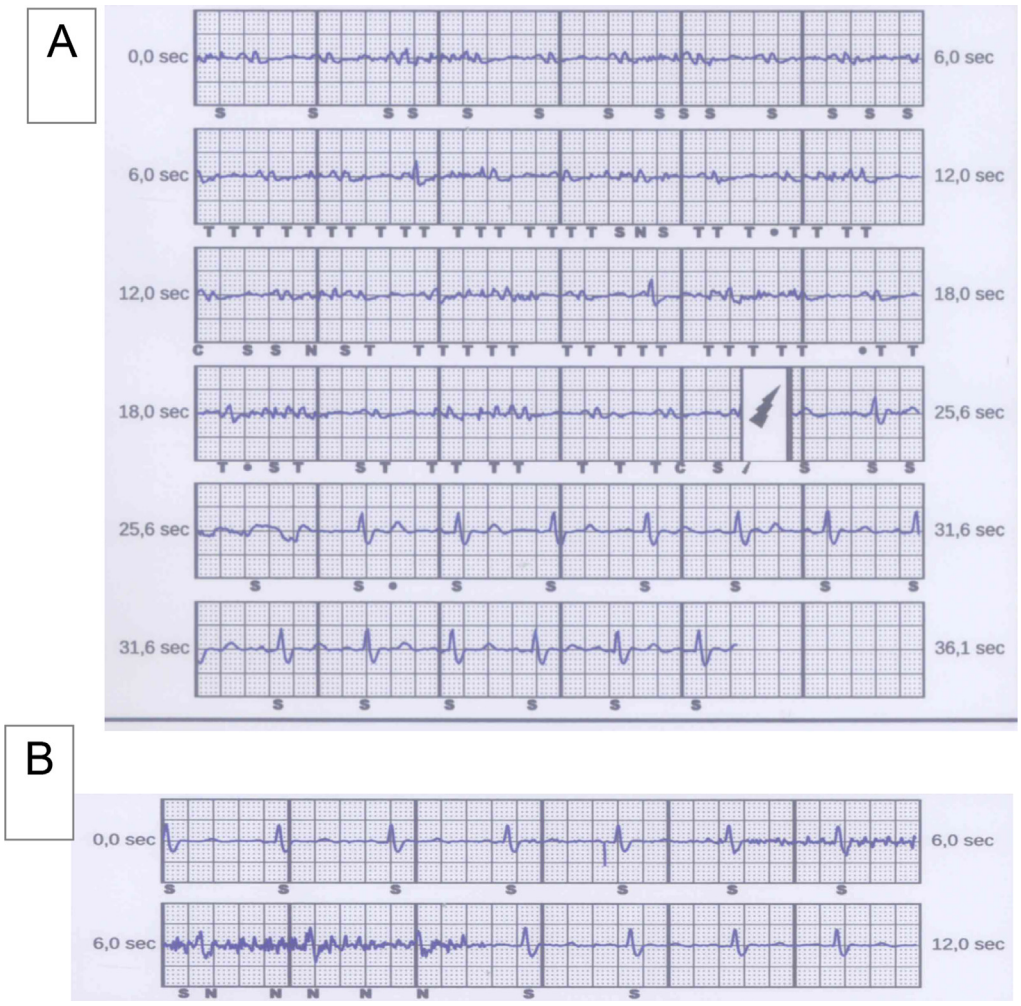

Fig. 1 – A – EGM of s-ICD shock. The EGM analysis revealed many irregular ventricular signals of low amplitude lasting 24 s interrupted by the shock of device; the shock was followed by sinus rhythm. B – Reproduction of myopotential signals during the visit. While the patient lifted up the cylinder, EGM showed altered ventricular signals, but this time ICD correctly classified them as "noise".

to the increase in heart rate, and it may lead to consequent potential modifications which can preclude eligibility. Unfortunately nowadays we have no data about the detection of malignant arrhythmias which starts during sinus tachycardia. In our opinion it is important to have at least 2/3 leads suitable in surface EKG screening template in order to minimize the risk of inappropriate shocks, with a better management of device-related oversensing. So probably the 2/3 configuration for eligibility may be the best and widely advisable criterion for eligibility.

4. Conclusion

Observing the EGM recorded by patient's device, after having excluded an episode of VT/VF by linking the EGM track with an

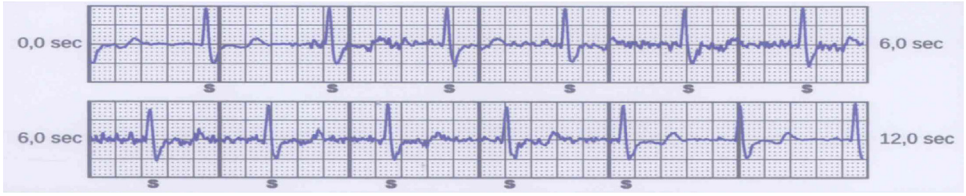

Fig. 2 – EGM during effort after new device configuration. With new sensivity settings, while patient handled the heavy cylinder, no noise was detected but only regular sinus rhythm. Comparing this EGM to Fig. 1, a higher signal amplitude can be noted (the gain was amplified 2X). (EGM: 25 mm/s; 5 mm/mV).

accurate anamnesis, the reasonable suspicion of inappropriate shock due to noise related to myopotential over-sensing was formulated. By recording intracardiac EGM we demonstrated that the noise was created by the activity of the pectorals muscles and we solved the problem of over-sensing changing the sensitivity of the device and the sensing vector. Anamnesis and clinical examination, together with a good knowledge of the problem, can often overcome advanced technology.

Conflicts of interest

All authors have none to declare.

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