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CASE REPORT

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Multiple shocks after upgrade of an implantable cardioverter-defibrillator to a cardiac resynchronization therapy-defibrillator device

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Abstract

Inappropriate shocks from implantable cardioverter-defibrillators (ICDs) may occur for many reasons. Inappropriate shocks are not simply painful inconveniences for patients; they also may result in the need for further operative procedures, and sometimes even death. Herein, we report the case of a patient who after upgrade of an ICD to a cardiac resynchronization therapy-defibrillator device (CRT-D), returned with multiple shocks due to altered sensing and defibrillation polarities that resulted from actual physical reversal of the distal (–) and proximal (+) lead terminals in the header of the device. (Cardiol J 2009; 16, 5: 473–476)

Key words: implantable cardioverter-defibrillator, cardiac resynchronization therapy, heart failure, shocks

Introduction

In recent years, with the establishment of the role of implantable cardioverter-defibrillators (ICDs) for secondary prevention of sudden cardiac death (SCD) in the survivors of cardiac arrest, and for primary prevention of SCD in select patients with ischemic and non-ischemic cardiomyopathy, the number of ICD implantations has increased.

Because of improvements in survival and heart failure status, ICDs incorporated in cardiac resynchronization therapy devices (CRT-D) are now also considered and implanted in patients with severe congestive heart failure and cardiac dyssynchrony. Additionally, ICDs have been shown to play an important role in the prevention of SCD in select patients with 'inherited' cardiac arrhythmic substrates. In spite of improvements in implantation methodology and device technology, because of the increased number of implantation of ICDs, the incidence of device-related complications may yet rise further.

One of these complications, inappropriate shocks, may occur due to many reasons. These include misinterpretation of supraventricular tachycardia as ventricular tachycardia, intracardiac oversensing (P-wave oversensing, R-wave double counting, T-wave oversensing), extracardiac oversensing (pectoral or diaphragmatic myopotentials), lead or connector problems (lead fracture, loose setscrew), or external noise from electromagnetic interference. While some of the causes of ICD malfunction may result from the software or random component failure, some may occur due to operator error at the time of implantation. Unfortunately, such an error may not become evident until late in the clinical course, and may often be picked up by a different operator/s at a different center.

Here, we report the case of a patient who after upgrade of an ICD to a CRT-D device returned with multiple shocks due to altered sensing and defibrillation polarities that resulted from actual physical reversal of the distal (–) and proximal (+) lead terminals in the header of the device.

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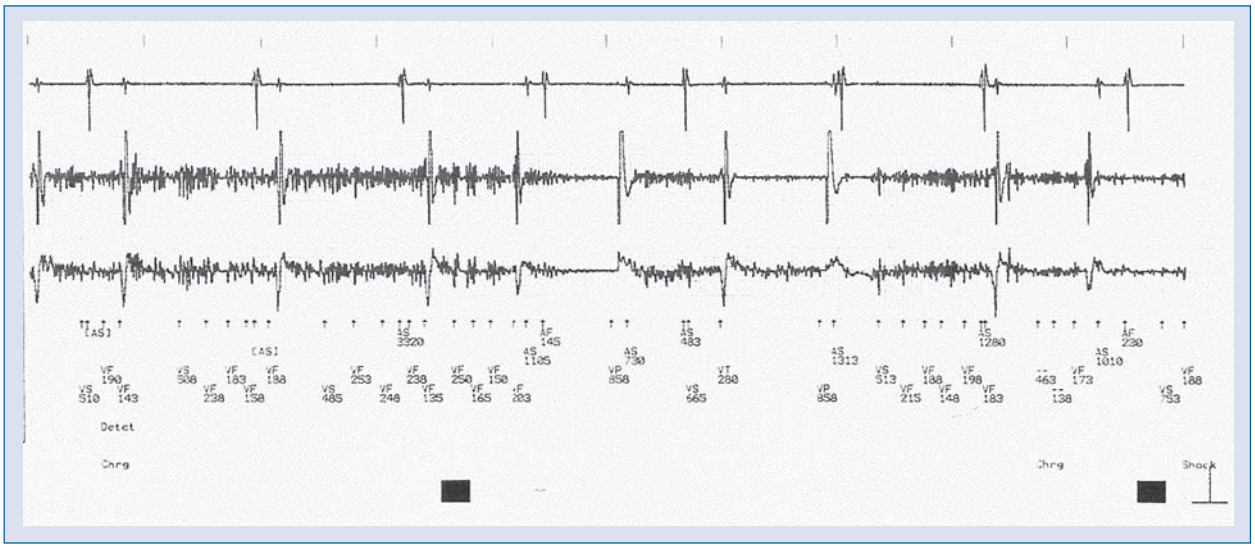

Figure 1. Interrogation of the defibrillator shows stored intracardiac electrograms (EGMs) of the event. The EGMs are recorded from the right atrial (RA) channel (top), the right ventricular (RV) pace/sense channel (middle), and the high voltage (HV) shock coil channel (bottom). The device misinterprets high frequency low voltage noise as ventricular sensed (VS), ventricular tachycardia (VT) and ventricular fibrillation (VF) events. When the therapy criteria for VF are met, the device charges (Chrg) and delivers shock (shock).

Case report

A 74 year-old man with ischemic cardiomyopathy who had undergone dual chamber ICD implantation four years ago presented to the hospital after receiving an ICD shock. He had not been followed up after his initial procedure. On interrogation, the device (Model 1853, Guidant-Boston Scientific, USA) was found to have delivered an appropriate shock for sustained ventricular tachycardia, even though surprisingly the battery had reached end-of-life status 13 months before presentation. Given his persistent NYHA class III heart failure symptoms, baseline left bundle branch block, and diminished left ventricular ejection fraction of 30%, he underwent an attempted upgrade to a CRT-D. The coronary sinus lead placement was unsuccessful, and hence the patient underwent surgical epicardial lead placement three days later.

The new system thus comprised the following components: a previously implanted right atrial lead (model 4086), a previously implanted right ventricular (RV) lead (model 0158), a new generator (model H217 Contak Renewal), and a new left ventricular lead (model 4047). All of these were manufactured by Guidant-Boston Scientific, USA. With this system, at the time of the surgery, during defibrillation threshold (DFT) testing, defibrillation was successfully accomplished with 25 J, providing a reasonable 10 J safety margin. The pacing threshold, sensing threshold, pacing impedance, and the high voltage (HV) shock impedance of the RV lead were 0.8 V at 0.5 ms, 16.0 mV, 500 Ω, and 36 Ω respectively. After a satisfactory post-operative clinical course and pre-discharge interrogation of the ICD for its appropriate function, the patient was discharged. As a routine post-operative instruction, the patient was advised to limit left arm movement, especially at the shoulder and to avoid lifting heavy objects for at least ten days.

He returned to the hospital six weeks later complaining of recurrent shocks from the ICD. Each shock occurred with left arm movement, predominantly when scratching the right side of the abdomen with his left hand. Interrogation of the device demonstrated many diverted charges, as well as 11 delivered shocks (Fig. 1). The pacing and sensing thresholds data and the pacing and shock coils impedances were all unchanged from the implant data. The findings on the intracardiac electrograms (EGMs) recorded during the shocks were reproduced with the left arm movement at the bedside. Chest X-ray did not demonstrate any apparent conductor or lead fracture.

The patient returned to the electrophysiology laboratory for further examination and potential revision of the system. The RV lead appeared intact. However, the proximal (+) superior vena cava and the distal (–) RV high voltage lead terminals were found to be reversed in the header of the ICD.

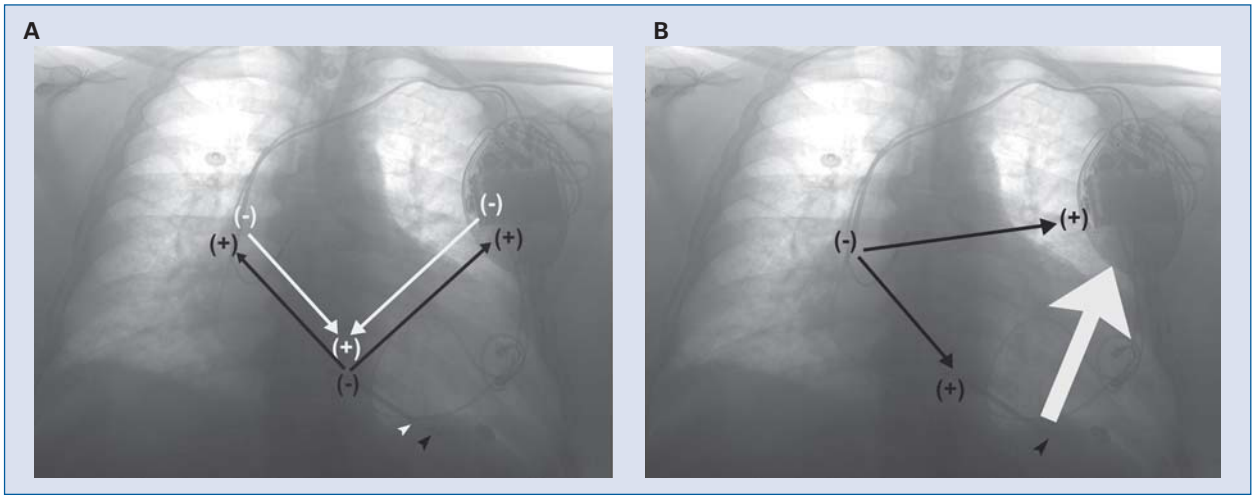

Figure 2. The chest X-ray shows cardiac resynchronization therapy-defibrillator device (CRT-D) system with the right ventricular (RV), left ventricular epicardial and the right atrial leads. As shown in (**A**), normal bipolar sensing vector is from the tip of the RV lead to the distal RV coil (black and white arrowheads respectively). With conventional connection, the defibrillator shock energy flows from the RV distal coil (–) to the superior vena cava (SVC) coil (+) and the generator (+) (black arrows). When the reversed lead polarity is 'programmed', the defibrillator shock energy flows from the SVC coil (–) and the generator (–) to the RV distal coil (+) (white arrows). In both cases, the shock energy is focused in the ventricle. As shown in (**B**), when the distal (–) and proximal (+) pins are physically reversed in the implantable cardioverter defibrillator header ports, a broad unipolar sensing configuration occurs between the lead tip and the generator (black arrowhead and a broad white arrow respectively), and the defibrillator shock energy flows from the SVC coil (–) to the generator (–) and to the RV distal coil (+) (black arrows).

It is also worth noting that the words 'proximal' and 'distal' on this four year old lead were difficult to read. Due to the battery drain from the multiple shocks and diverted charges, a new CRT-D device was implanted as recommended by the manufacturer. The patient did well post-operatively and had no further inappropriate shocks or device malfunction during a follow-up period of six months.

Discussion

For pacemakers and ICDs to function normally, it is important that they appropriately sense and detect intracardiac electrical potentials. Errors in sensing function of the devices leading to either withholding or delivery of therapy are still causes of concern, despite advances in device technology. ICD malfunction may be due to oversensing of intracardiac events such as R-wave double counting, T-wave oversensing and/or oversensing of extracardiac potentials such as pectoral or diaphragmatic myopotentials or external noise from electromagnetic interference, resulting in inappropriate shocks. Sensing failure may also result from lead or connector problems, for example coil fracture or a loose set-screw.

Pertinent to our case, normal RV lead parameters made the possibility of lead fracture unlikely. The presence of high frequency, low-amplitude noise with arm movement raised the suspicion of myopotential oversensing. Diaphragmatic myopotential oversensing is more common during periods of straining or valsalva maneuvers, while arm movement makes pectoral myopotential oversensing more likely.

In our patient's ICD system, the RV lead was an integrated bipolar lead. In this lead, bipolar sensing is accomplished from the tip of the RV lead to the distal RV coil (black and white arrowheads respectively, Fig. 2A). The proximal (+) port in the header is hardwired to the generator. Therefore, when the distal (–) and proximal (+) pins are physically reversed in the ICD header ports, a broad unipolar sensing configuration occurs between the lead tip and the generator itself (black arrowhead and a broad white arrow respectively, Fig. 2B).

In addition, unlike reversing the shocking polarity with electronic programming (Fig. 2A), with physical reversal of the pins in the header, a shocking configuration occurs which diverts energy away from the ventricles, potentially leading to high DFTs or inability to defibrillate (Fig. 2B). This latter

point was reported by Maagh et al. [1] in a similar case involving a patient with a failed defibrillation and inability to determine DFTs. Their case also involved a Guidant-Boston Scientific ICD, as did the other reports [2, 3]. However, a unique case of repeated, inappropriate shock delivery due to abnormal sensing of external noise resembling 60-Hz alternating current on the sensing channel of the ICD that resulted from the reversal of the pins in the header in a Medtronic device has also been reported [4].

Inappropriate shocks are not simply a painful inconvenience for patients; they may lead to the need for further operative procedures, and rarely even death, as in the recent case reported by Catanchin et al. [5]. Troubleshooting ICD malfunction requires detailed analysis of all available data, including chest x-ray, programmer interrogation, and evaluation of clinical factors such as electrolyte abnormalities, presence of myocardial ischemia, etc. Clues to the diagnosis of our patient included the normal lead parameters, the EGM appearance during the inappropriate shocks, and the ability to reproduce the finding with left arm movement. The presence of equal degrees of noise on both the shock coil and RV pace/sense channels with normal RV pace/sense parameters and the pacing and HV impedances further suggest HV coil polarity reversal. In addition, one may see farfield P-waves on the RV lead due to the broad unipolar sensing configuration. Patients with this problem often present in the first month after implantation, when the incision has healed and they begin using their arms more.

Conclusions

Our case demonstrates the risk of myopotential oversensing and inappropriate shocks in the setting of inadvertent physical reversal of the distal (–) and proximal (+) lead terminals of an integrated bipolar ICD lead. This problem should be suspected in the presence of inappropriate shocks early after implant due to myopotential oversensing, especially when other lead parameters are normal. In the future, this risk may be removed with the use of a 'universal' IS-4 defibrillator lead comprising only one terminal. In the meantime, vigilance at the time of device implantation, and more so at generator change-outs where one may encounter poor legibility of the manufacturer's symbols and letters on older leads, is essential to avoid this complication.

Acknowledgements

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