Electromagnetic Interference from a Muscle Stimulation Device Causing Discharge of an Implantable Cardioverter Defibrillator: Epicardial Bipolar and Endocardial Bipolar Sensing Circuits Are Compared

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GLOTZER, T.V., ET AL.: Electromagnetic Interference from a Muscle Stimulation Device Causing Discharge of an Implantable Cardioverter Defibrillator: Epicardial Bipolar and Endocardial Bipolar Sensing Circuits Are Compared. *This case report is about two patients with two different types of ICDs who underwent electrical muscle stimulation (EMS) therapy. In one patient with an ICD that has epicardial screw-in bipolar sensing leads, electromagnetic interference (EMI) from the EMS device caused the delivery of an inappropriate ICD discharge. In a second patient with an ICD with endocardial true bipolar sensing, there was no evidence of EMI during the EMS therapy despite all of our attempts to reproduce it. The sensing circuits in the two different ICDs are compared. (PACE 1998; 21:1996–1998)*

electrical muscle stimulation, implantable cardioverter defibrillator, electromagnetic interference

Introduction

Electromagnetic interference (EMI) can disrupt normal implantable cardioverter defibrillator (ICD) function. Multiple devices have been reported to interfere with ICD function causing inappropriate ICD discharges, as well as deactivating sensing altogether.[1–6] In addition, there are several reports describing the interaction between pacemakers and transcutaneous or implanted electrical nerve stimulators.[7,8] Currently, there are no reports involving transcutaneous electrical nerve stimulation (TENS) or electrical muscle stimulation (EMS) and ICD interactions. In the following case report, EMI during EMS therapy caused an inappropriate discharge of an ICD. The mechanism of EMI is explored.

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Case Report

The first patient is a 55-year-old man with an idiopathic dilated cardiomyopathy and a history of cardiac arrest. Electrophysiological studies did not reveal any inducible arrhythmias, and he underwent implantation of a Telectronics Guardian model #4204 ICD (Telectronics Pacing Systems Inc., Englewood, CO, USA). The device was implanted in the abdomen and connected to Telectronics epicardial screw-in rate sensing leads model numbers 033–572. The ICD was programmed to detect and treat all ventricular rates $>$ 182 beats/min for 8 of 10 beats.

Three years later, the patient underwent EMS therapy for low back pain. The two electrodes were placed in the standard position over the lower back on either side of his spine to stimulate the lower back extensor muscles. The EMS unit was a Rich-Mar VI (Rich-Mar Inc., Inola, OK, USA) that consisted of a solid state blocking oscillator that provides EMS voltages of selectable frequencies from 1–60 pps. The output voltage is an asymmetrical biphasic wave that can be individually adjusted in intensity from 0–25 V.[9] In this case, the maximum

voltage that the patient could tolerate was delivered, and the frequency of delivery was at a dial setting of 60 pps. The patient received an ICD discharge during the therapy session.

During normal sinus rhythm seen on the intracardiac electrograms, the main timing event channel sensed electrical activity at 152-ms intervals (Fig. 1). The EMI was sensed by the ICD and caused a 20-J shock delivery. A similar tracing without EMI is shown as a reference to demonstrate the appearance of the intracardiac electrogram and the main timing event channel during normal sinus rhythm (Fig. 2).

The second patient was a 70-year-old man who also had a nonischemic cardiomyopathy. Frequent episodes of nonsustained polymorphic ventricular tachycardia correlating with symptoms of presyncope prompted electrophysiological study that revealed no inducible ventricular arrhythmias. A Medtronic Jewel model 7219C active can model ICD (Medtronic Inc., Minneapolis, MN, USA) was implanted in the left pectoral region and connected to the Medtronic Transvene lead model 6936 that has true bipolar sensing from the endocardial lead. Subsequently, the patient was scheduled to receive EMS therapy to his left forearm. Because of the history of ICD discharge during EMS therapy in the previous case, we sought to determine the extent of possible EMI in this patient.

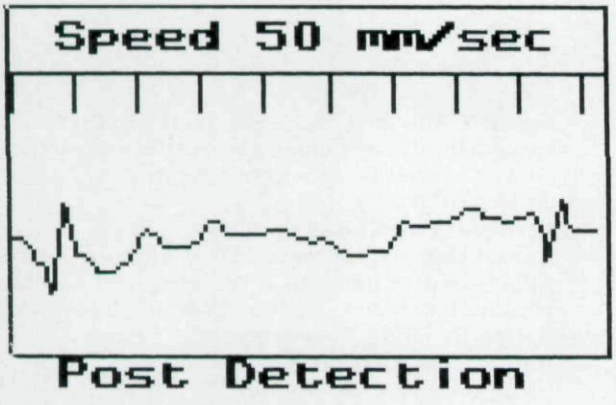

Figure 1. *The main timing event channel from the Telectronics 4204 device is displayed on the top line. The intracardiac electrogram obtained from the rate sensing leads is displayed on the second line. The device is sensing electrical activity at 152-ms intervals while the intracardiac electrogram reveals only two QRS complexes.*

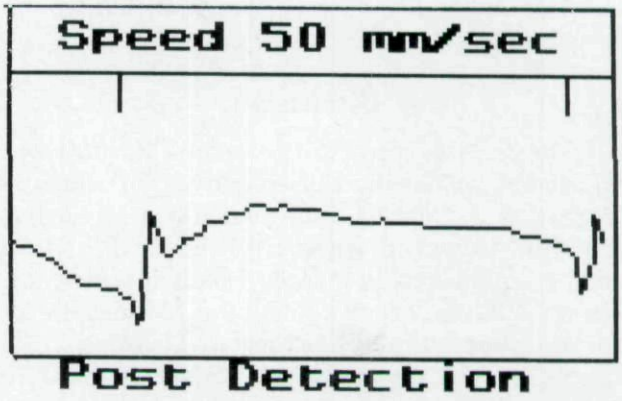

Figure 2. *The main timing event channel from the Telectronics 4204 device is displayed on the top line. The intracardiac electrogram obtained from the rate sensing leads is displayed on the second line. The device appropriately senses one event for each QRS complex seen on the intracardiac electrogram.*

After obtaining informed consent, we delivered maximal intensity, high frequency EMS therapy to multiple standard locations in close proximity to the myocardium (left shoulder, left upper back, left upper abdomen), in addition to the extensor muscles of the lower back as described in the previous case, and the left forearm.

The EMS device used was an Empi FOCUS Neuromuscular Stimulation (Empi Inc., St. Paul, MN, USA) system that is capable of transmitting two different waveforms; a balanced asymmetrical biphasic waveform and a symmetrical biphasic waveform. Each waveform was tested in each of the anatomical locations. The intensity of the stimuli is adjustable from 0–100 mA at a 300 us pulse width. The rate of stimulus delivery is 25, 35, or 50 pps.[10] At each anatomical location, the intensity of stimulation was the maximum that the patient could tolerate and the frequency of stimulation was 50 Hz.

During each EMS therapy session, the ICD arrhythmia detection was turned off. In this mode the ICD senses normally, but therapy delivery is disabled. The programming head was left in position over the ICD so that intracardiac electrograms and Marker Channels™ (Medtronic Inc,) could be monitored throughout therapy delivery. Regardless of the anatomical location of EMS, intensity of the pulses, or shape of the waveform, there was absolutely no evidence of inappropriate

sensing by the ICD with endocardial true bipolar sensing.

Discussion

In the first case, EMI from an EMS unit was sensed by an ICD and caused delivery of a therapy intended to treat an abnormal intrinsic cardiac rhythm. However, when we tried to reproduce this phenomenon in a second patient with a different ICD, we saw no evidence of EMI despite all of our attempts to reproduce it. Therefore, EMI from EMS therapy may not be universal. Possibilities for the differences we found include: a difference in the two EMS units, differences in the sensing algorithms of the two different ICD devices, or a difference between the position and type of the sensing leads.

A difference in the EMS units is an unlikely cause for our findings because both EMS units deliver waveforms with identical configuration and frequency, and the intensity of stimulation was adjusted to the maximum that the patient could tolerate in each case.

The sensing algorithm of the Telectronics Guardian device was programmed to 2 mV and increased by 50% during arrhythmia detection.[11] In the first case, the epicardial bipole detected the EMS pulses that triggered firing of the ICD. The sensing algorithm of the Medtronic ICD adjusts automatically to avoid sensing small electrical signals during normal cardiac rhythm.[12] However, had the endocardial bipole detected the pulses, the high frequency of delivered impulses from EMS therapy in the second case should have raised the sensitivity of the ICD device to the maximum.

The sensing electrodes in the two different patients are in different anatomical locations: endocardial versus epicardial position. Most prior reports of EMI interfering with ICD function involve older ICDs with epicardial screw-in sensing leads.[1,3] One can raise speculation that endocardial bipolar sensing is better shielded from EMI because of either the spatial orientation of the endocardial bipole, or merely the endocardial location.

More data is required to determine the exact mechanism of EMI, and to make recommendations regarding newer ICD devices. However, the available data would suggest that ICDs should be inactivated prior to EMS therapy at any site on the body.

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