

Unipolar Defibrillator?

BEHZAD B. PAVRI, REGINALD T. HO, VIKAS PATEL,
DAVID J. CALLANS, SHANE FOLEY,* and DUSAN Z. KOCOVIC

From the Department of Medicine, Division of Cardiovascular Medicine,
Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania and

*Guidant Corporation, St. Paul, Minnesota

PAVRI, B.B., ET AL.: Unipolar Defibrillator? *An unusual case of "unipolar" pacing and myopotential oversensing leading to an inappropriate ICD shock in a patient with an implanted defibrillator is reported. The reasons for unipolar behavior in a system using a committed bipolar device are discussed. (PACE 2001; 24:244-246)*

unipolar ICD

Case Report

A 59-year-old man with a history of paroxysmal atrial fibrillation, sinus bradycardia, coronary artery disease, and remote coronary artery bypass grafting was referred for implantation of a cardioverter defibrillator (ICD) because of severely reduced left ventricular function, nonsustained ventricular tachycardia, and inducible monomorphic ventricular tachycardia.

A CPI Ventak AVIII DR 1831 (Cardiac Pacing, Inc., St. Paul, MN, USA) pulse generator was implanted with a Medtronic (Minneapolis, MN, USA) Sprint 6945 dual coil, integrated bipolar lead positioned at the right ventricular (RV) apex and a Pacesetter (Siemens Pacesetter, Inc., Sylmar, CA, USA) Tendril Dx 1388T bipolar lead in the right atrium. At implantation, the P and R waves measured 4.6 mV and 9.0 mV, and the pacing thresholds were 0.6 V at 0.5 ms for the atrium and ventricle. The bipolar pacing impedance for the atrial and ventricular leads were 396 ohms and 506 ohms, respectively. Successful defibrillation was achieved on two of three occasions with 21 J. The electrocardiogram (ECG) recorded after ICD implantation is shown in Figure 1.

Three days after implantation, the patient received a shock from the ICD while turning over in bed. The patient denied palpitations or dizziness. The following day, device interrogation demonstrated an R wave of 9.3 mV, a ventricular pacing threshold of 0.6 V at 0.5 ms, and a ventricular bipolar pacing lead impedance of 455 ohms that did not vary with repeated testing. Electrograms from the device were retrieved (Fig. 2A). Real-time electrograms recorded during the performance of

isometric pectoral muscle contraction are shown in Figure 2B. As a temporizing measure, the sensitivity of the ventricular channel was reprogrammed to the "least sensitive" setting to prevent further shocks.

What is the mechanism for "unipolar" pacing (large pacing artifacts) and pectoral muscle myopotential oversensing in a patient with a system using a committed bipolar defibrillator?

Discussion

This patient appears to have unipolar sensing and pacing, which is not possible with a properly functioning bipolar ICD system. An insulation breach may cause myopotential oversensing and unipolar pacing artifacts, but the bipolar pacing impedance would be abnormally low.

Reversed connections at the ICD header can explain all the features of this case. In a triad defibrillator system with normal connections (Fig. 3A), the defibrillation pathway is bidirectional from the RV coil (DF-), to the superior vena caval (SVC) coil, (DF+) and the housing of the pulse generator (DF+). Using an integrated bipolar defibrillator lead, sensing and pacing always occur between the tip of the lead (cathode) and the distal coil (anode.) The RV coil serves as the cathode for defibrillation and as the anode for pacing and sensing.

If, however, the connections at the ICD header are reversed (the RV coil is inserted into the DF+ port, and the SVC coil into the DF- port (Fig. 3B), the defibrillation and sensing/pacing pathways are altered. Defibrillation lead polarities become reversed so that defibrillation occurs from the SVC coil (DF-), to the RV coil (DF+) and pulse generator that remains DF+. Because of the proximity of the SVC coil to the pulse generator and the large surface area of the device, most of the defibrillation energy is shunted along the upper border of the heart and bypasses the septum and left ventricle. This diversion of energy away from the heart

Address for reprints: Behzad B. Pavri, M.D., Hospital of the University of Pennsylvania, 3400 Spruce St., Philadelphia, PA 19104. Fax: (215) 662-2879.

Received January 10, 2000; revised March 7, 2000; accepted April 4, 2000

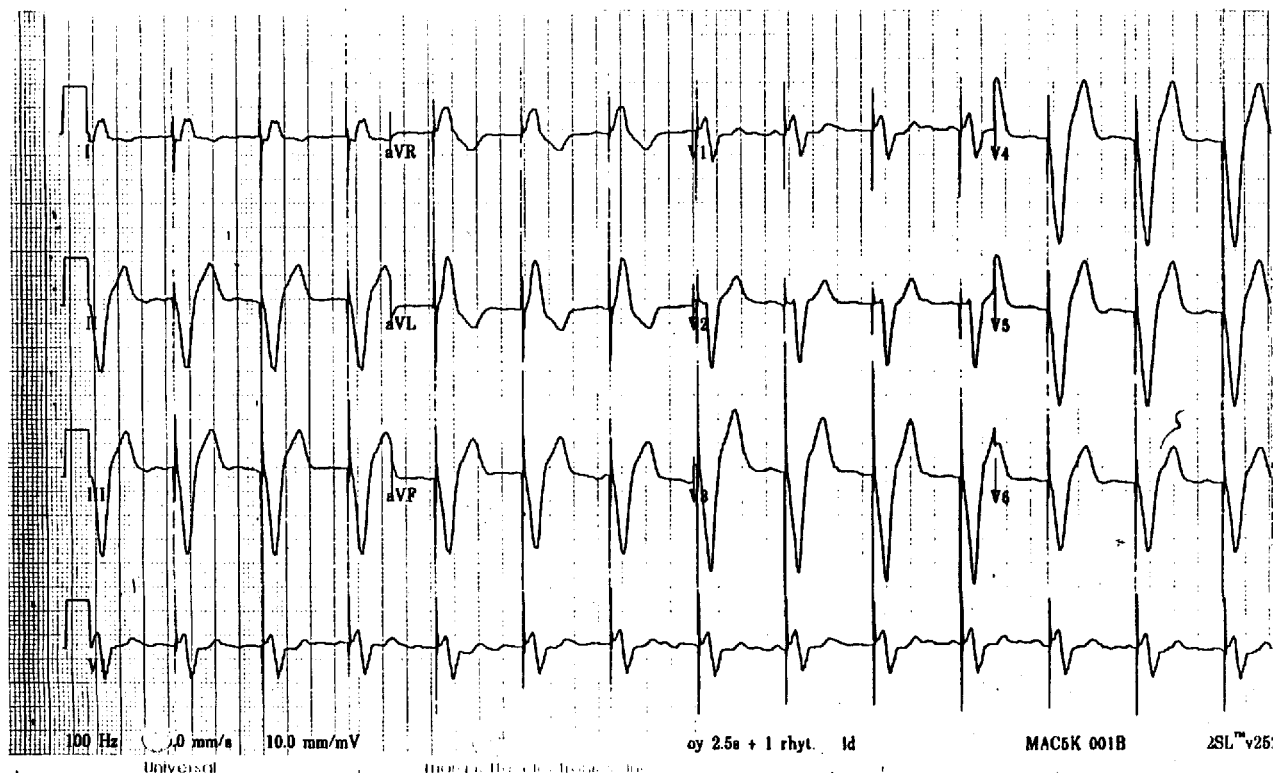


Figure 1. A 12-lead electrocardiogram obtained after ICD implantation is shown. The rhythm is atrial fibrillation with electronic ventricular pacing with large amplitude pacing artifacts consistent with unipolar pacing configuration.

may increase the defibrillation threshold. The pulse generator and RV coil are electrically common and form the anode with the tip remaining as the cathode. Therefore, the generator becomes incorporated into sensing and pacing as part of the proximal electrode. Pacing energy is delivered from the ventricular lead tip to the device, generating unipolar pacing spikes on the ECG. The large sensing dipole that develops between the lead tip and the pulse generator allows the detection of pectoral muscle myopotentials. This would not be a problem with a dedicated bipolar lead.

Based on this reasoning, the patient was taken back to the electrophysiology laboratory for revision of the ICD system. It was immediately confirmed that the RV and SVC coils were indeed reversed in their connections at the header. The leads were disconnected and ventricular lead testing with an external pacing system analyzer

demonstrated a bipolar R wave of 11.5 mV, pacing threshold of 0.6 V at 0.5 ms, and a bipolar pacing lead impedance of 456 ohms. The leads were correctly reconnected and successful defibrillation was now achieved twice with 17 J; lower energies were not tested. The 12-lead ECG following revision no longer revealed the large pacing spikes that were evident in Figure 1.

In summary, this case represents a rare cause for unipolar sensing and pacing by a committed bipolar ICD system due to reversal of the RV and SVC coil connections at the device header. This configuration resulted in myopotential oversensing and inappropriate shocks from the defibrillator. Careful attention to the 12-lead ECG following ICD implantation using an integrated bipolar lead should raise suspicion of a defibrillator lead polarity reversal if large amplitude pacing artifacts are seen.

