

# An ICD case: “spike quiz”

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## Case presentation

This is the case of a 60-year-old man with three-vessel coronary artery disease and a first myocardial infarction in 1998. The ejection fraction (EF) was 50% and functional status New York Heart Association (NYHA) class I. In 2002, he was referred to the hospital after an aborted sudden death secondary to ventricular fibrillation (VF). In accordance with current guidelines, after a reversible cause a single chamber implantable cardioverter defibrillator (ICD) Biotronik Lumos VRT was implanted. The device was programmed in a VVI 40 bpm mode, with bipolar pacing and sensing activity 2.5 V @ 0.4 ms for the pacing amplitude. The tachycardia zone was set to 170

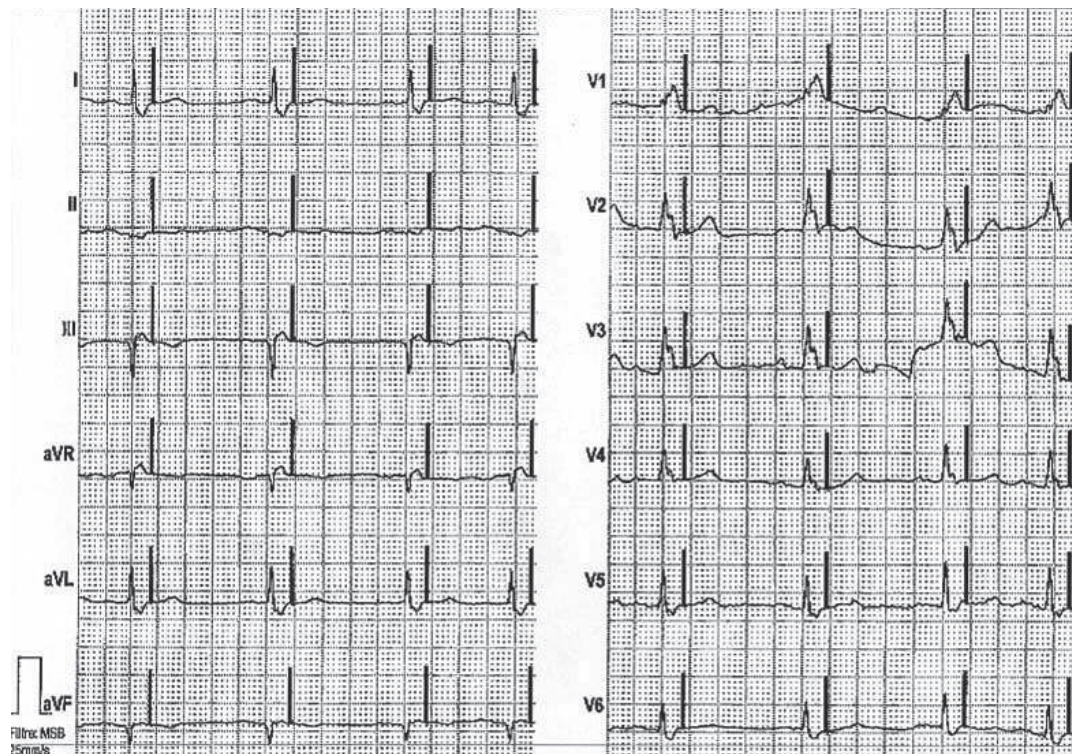
bpm (antitachycardia pacing [ATP] and shock) and >220 bpm (shock only). The device was changed in 2006. No shocks have been delivered since the implantation.

In February 2012, the latest usual device follow-up was normal except for a low voltage and high battery impedance close to elective replacement indicators. The sensing and stimulation thresholds were in the normal range. The pacing and shock impedance were also normal. No events were retrieved from Holter memories.

In March 2012, the device was replaced with a new model single-chamber ICD Biotronik Lumax 540 VR-T. At the end of the procedure, the testing was perfect, a VF (T wave shock) was induced and defibrillated at 20 Joules.

**Figure 1**

ECG and fax from the cardiologist. Observe a unipolar spike just after each QRS.



### Funding / potential

**competing interests:** No financial support and no other potential conflict of interest relevant to this article was reported.

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Figure 2

Biotronik programmer's screen.

AF = atrial fibrillation; AT = atrial tachycardia; IEGM = intracardiac electrogram; RV = right ventricle; SVT = supraventricular tachycardia

Overview	Bradycardia	Detection	VT1	VT2	VF	Patient	Diagnostics/HM
<b>Home Monitoring</b>			<b>Statistics</b>				
Home Monitoring		<b>ON</b>	AT/AF rate				<b>200</b> ppm
Time of transmission		<b>01:00</b> hh:mm	Start rest. period				<b>02:00</b> hh:mm
IEGM for therapy episodes		<b>OFF</b>	Rest. period dur.				<b>04:00</b> hh:mm
IEGM for monitoring episodes		<b>OFF</b>	Auto impedance measurement				<b>ON</b>
Periodic IEGM		<b>OFF</b> Months	AV delay adj. sensing test				<b>300</b> ms
Ongoing atrial episode		<b>12</b> h	Thoracic impedance				<b>OFF</b>
Thoracic impedance →		<b>ON</b>	<b>Autom. threshold monitoring (ATM)</b>				
<b>Recording episodes</b>			ATM RV				<b>ON</b>
For AT/AF		<b>ON</b>					
For SVT		<b>ON</b>					

The day after the replacement, ICD interrogation showed normal functioning of the device and the patient went home.

In September 2012, we received a call and a fax from the patient's cardiologist: he did not understand the routine electrocardiogram (ECG) registered in his patient (fig. 1). There were unipolar spikes in all derivations just after the QRS. The spikes were in the physiological refractory period of native ventricular depolarisation and therefore produced no ventricular capture.

### Questions

- Could it be a malfunction of the device?
- If yes, what are the possible causes of this malfunction?

We suspected a system malfunction with a ventricular sensing and pacing defect because the device seemed to be functioning in a VVT mode despite being programmed to VVI. The latter can easily be explained by the pacing delivery during the ventricular refractory period preventing capture. There was no lead impedance change, so conductor fracture, loose setscrew and insulation defect were unlikely.

### We could also exclude

1. Lead maturation because the ICD was implanted in 2002;
2. Lead dislodgment because the X-ray was normal and the impedance/threshold were stable;
3. Programming error because there was the same programme;
4. Drug or metabolic causes because blood tests were normal (no electrolyte disturbances, no hyperkalemia and acidosis);
5. Artifact because the two ECGs from the cardiologist and our department were identical.

### The answer came from the Biotronik's engineers ...

This was actually not the first time Biotronik had been contacted because of this unusual spike in French patients. The answer was quite simple and corresponds to a programmable parameter: the transthoracic impedance measurement also called the lung oedema sensor.

On the programmer screen, you can find this parameter in the diagnostic/home monitoring window, where by default it is programmed "on" (fig. 2). The thoracic impedance measurement [1] is based on the subthreshold pacing pulse delivered between the right ventricular coil and can (unipolar pacing).

There is no negative effect for the patient because the energy of the test pulse is too small and cannot capture the heart (1 V @ 0.03 ms) and the test pulse meets refractory cells since it is coupled 100 ms after V<sub>s</sub> or V<sub>p</sub>. Thoracic impedance is measured in Biotronik devices during the first 1,096 seconds every hour.

Impedance is equivalent to conductance that is equivalent to the resistance of the current between ring/coil and the can. When heart failure is worsening, there is an accumulation of fluid in the lung leading to a decrease in the thoracic impedance [2]. The thoracic impedance measurement is inversely correlated with pulmonary capillary wedge pressure and fluid balance. It is decreased before the onset of patient symptoms and hospital admission. Monitoring may provide early warning of cardiac decompensation and could be useful for the titration of medication [3] as already described by the optivol fluid index in Medtronic devices [4]. Some false positives with acute pulmonary disease should be ruled out.

This feature, which is nominally programmed, produces very unusual unipolar spikes in patients implanted with the latest generation of the Biotronik ICDs. Cardiologists should be warned about this particularity.

### References

1. Tang WH, Tong W. Measuring impedance in congestive heart failure: Current options and clinical applications. *Am Heart J.* 2009;157(3):402–11.
2. Wang L, Yu CM, Chau E. Prediction of CHF hospitalization by ambulatory intrathoracic impedance measurement in CHF patients is feasible using pacemakers or ICD lead systems. *PACE.* 2003;26:959.
3. Yu CM, Wang L, Chau E, Chan RH, Kong SL, Tang MO, et al. Intrathoracic Impedance Monitoring in Patients with Heart Failure. *Circulation.* 2005;112:841–8.
4. Yang XW, Hua W, Ding LG, Wang J, Zheng LH, Li CQ, et al. Optivol fluid index predicts acute decompensation of heart failure with a high rate of unexplained events. *J Geriatr Cardiol.* 2013;10(3):253–7.