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The impact of the electromagnetic field generated by the left ventricular assist device on a leadless pacemaker function

Short title: Leadless pacemaker and left ventricular assist device interference

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Patients requiring left ventricular assist devices (LVADs) constitute a therapeutic challenge because of the increased risk of hemorrhagic, thrombotic and infectious complications, particularly in case of invasive treatment. Most patients with LVADs were previously equipped with implantable cardioverters-defibrillators (ICDs). Decision concerning their secondary implantation is difficult because of adverse events and potential interferences between LVADs and cardiac implantable electronic devices (CIEDs) such as inhibition of pacing or ventricular arrhythmia therapies as well inadequate defibrillations. These complications are results of improper detection of intrinsic heart activity affected by the electromagnetic field generated by LVADs, as the one of the components of the pump motor is a magnet.

Current reports remain contradictory regarding ICD impantation in patients with LVADs [1]. According to the Expert Consensus on Long-term Mechanical Circulatory Support of European

Association for Cardio-Thoracic Surgery from 2019, routinely de novo implantation of an ICD in primary prevention is not recommended [2]. The Scientific Statement From the American Heart Association from 2019 also indicates no survival benefit for ICD therapy in patients with continous flow LVADs [3].

In the presented case, LVAD HeartMate3 (Abbott, St.Paul, MN, US) was implanted in 2017. In 2020, the patient was subjected to complete explantation of the ICD (primary prevention) due to fungal infection of the device pocket six years after ICD implantation. At 2022, an intermittent third-degree atrioventricular block was diagnosed. The minimal heart rate was 22 beats per minute. Conduction disturbances were asymptomatic thanks to pump function, however prolonged deacrease of heart rate may lead to improper filling of the right and left ventricle with symptoms of the heart failure and the risk of thrombus formation [4].

A decision was made to implant a leadless pacemaker Micra^{TM}VR (Medtronic, Minneapolis, MN, US), due to paroxysmal atrial fibrillation and risk of improper function of atrioventricular model as it is based on detection of mechanical atria and ventricles work, which were not fully physiological as the left ventricle was unloaded by LVAD.

The surgery was performed at INR 2.6 with a typical technique (Position of the leadless pacemaker, Supplementary material, *Figure S1*).

Parameters: R wave amplitude — 5.4 mV (programmed sensitivity 2 mV), resistance-660 ohm, threshold of stimulation — 0.75V/0.24 ms (Figure 1A).

A neighborhood of LVAD may lead to difficult to predict disturbances in cardiac implantable electrotherapy devices function. In that case, at sensing of 2 mV, the lack of detection of the heart activity and pacing, which should be its consequence, were present (Figure 1B).

Pacemaker sensing determines the possibility of detection of intrinsic cardiac electrical impulses. It indicates that heart stimuli with amplitude lower than programmed will not be “seen” by a pacemaker, what provides to pacing. Too low programmed sensing value may cause detection not only heart activity, but also other changes in the electrical field, not connected with the heart work, and stop stimulation.

The highest value of sensitivity provided to proper detection and stimulation was 0.9 mV (Figure 1C). The correct function of the pacemaker in that setting and recurrence of the abnormality after increase the sensitivity value was confirmed in 1-year follow-up, what suggests an evoked by the electromagnetic field undersensing and lack of reaction of the pacemaker on that.

An explanation may constitute as well a weak telemetry connection between the pacemaker and a programmer, what is also an effect of the electromagnetic field impact, is partially dependent on the distance between the pacemaker and LVAD, and was numerously reported [5].

Another problem with the electromagnetic field is a proper interpretation of ECG records due to artefacts. Impellers of the HeartMate3 devices run with an oscillating frequency of 83.3–100 Hz, most of ECG machines are enabling to register changes of the electric field within 0.16–150 Hz range, what leads to record part of the electromagnetic spectrum as the heart activity (Figure 1D and E).

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/kardiologia_polska.

Article information

Conflict of interest: MS and AB declare travel reimbursement connected with participation in conferences by Abbott Inc. AS is the current President Elect of the Heart Rhythm Section of the Polish Cardiac Society. He reports a relationship with Medtronic Inc., Biotronik Inc., Boston Scientific Inc. and Abbott Inc. which includes paid expert testimony and travel reimbursement. OK is a member of the Main Board of the Polish Cardiac Society and consultant of the Agency for Health Technology Assessment and Tariff System. He reports a relationship with Medtronic Inc. Biotronik Inc., Boston Scientific Inc. and Abbott Inc., which includes consulting or advisory, speaking, and lecture fees. PP declares no conflicts of interest.

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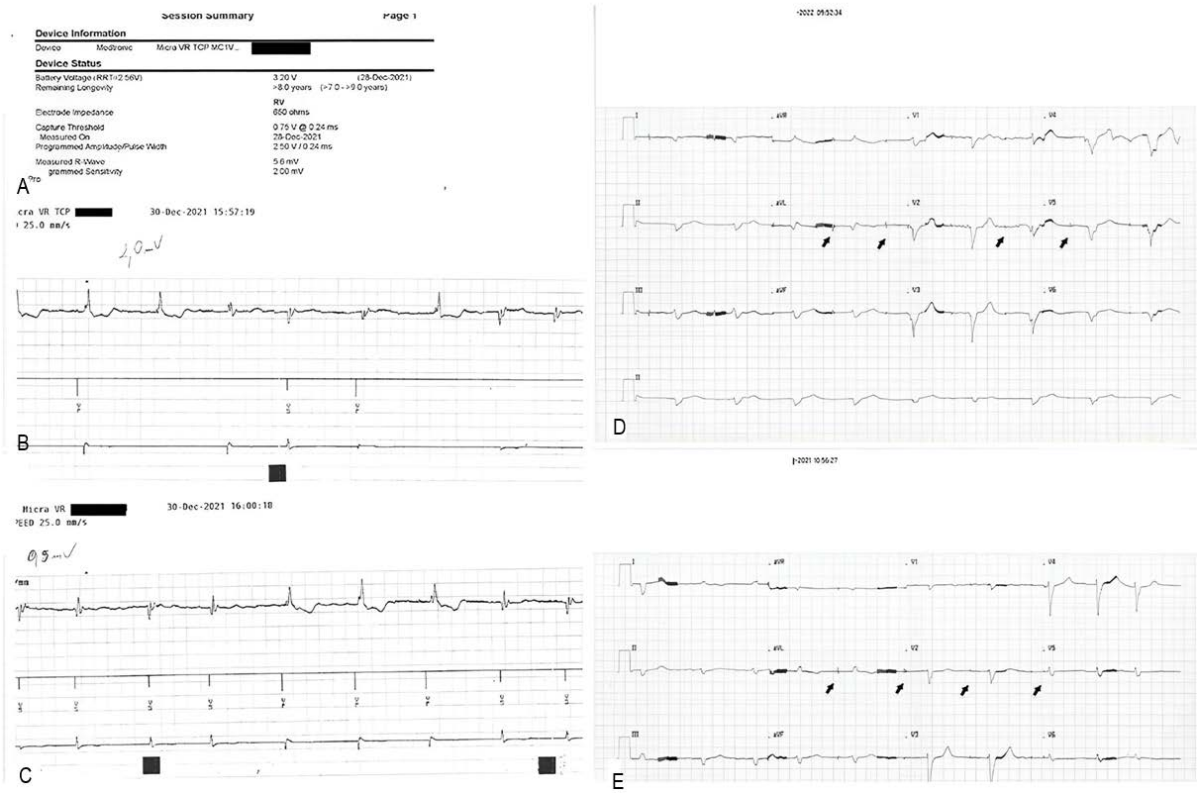

Figure 1. A. Implanted pacemaker settings directly after surgery. **B.** The lack both detection of intrinsic electrical activity of the heart and pacing (middle and third line) with sensing programmed at 2 mV. **C.** Correct detection and pacing with pacemaker's sensing programmed at 0,9 mV. **B.** and **C.** First line — superficial electrocardiogram (ECG) record; third line — electrical activity of the heart detected by the pacemaker; middle line — markers of electrical activity detected by the pacemaker; VS: intrinsic sensed ventriculars stimulus, VP: paced

ventricular stimulus). **D.** ECG record after implantation of the leadless pacemaker. Arrows indicate fake spikes suggesting ineffective pacing and improper function of the pacemaker. **E.** For comparison ECG record of the same patient before implantation of the pacemaker with the same fake spikes