Impact of the electromagnetic field generated by the left ventricular assist device on leadless pacemaker function

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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 the case of invasive treatment. Most patients with LVADs were previously fitted with implantable cardioverters-defibrillators (ICDs). Decision on 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 as well inadequate defibrillations. These complications result from improper detection of intrinsic heart activity affected by the electromagnetic field generated by LVADs, as one of the components of the pump motor is a magnet.

Current reports remain contradictory regarding ICD implantation in LVAD patients [1]. According to the 2019 Expert Consensus of European Association for Cardio-Thoracic Surgery on Long-term Mechanical Circulatory Support, routine *de novo* implantation of an ICD in primary prevention is not recommended [2]. The 2019 Scientific Statement from the American Heart Association also indicates no survival benefit of ICD therapy in patients with continuous flow LVADs [3].

In the present case, LVAD HeartMate3 (Abbott, St. Paul, MN, US) was implanted in 2017. In 2020, the patient underwent complete explantation of the ICD (primary prevention) due to a fungal infection of the device pocket six years after ICD implantation. In 2022, an intermittent third-degree atrioventricular block was diagnosed. The minimal heart rate was 22 beats per minute. Conduction disturbances were asymptomatic thanks to the LVAD pump, however a prolonged deacreased in the heart rate may lead to improper filling of the right and left ventricle with symptoms of 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 the risk of improper function of the atrioventricular model, as it is based on detection of mechanical atria and ventricles work, which were not fully physiological, since the left ventricle was unloaded by the LVAD.

The surgery was performed at international normalized ratio 2.6 with the typical technique (position of the leadless pacemaker, Supplementary material, *Figure S1*).

The pacemaker parameters directly after implantation equalled: R wave amplitude — 5.4 mV (programmed sensitivity 2 mV), resistance — 660 ohm, threshold of stimulation — 0.75 V/0.24 ms (Figure 1A).

LVAD may lead to difficult-to-predict disturbances in functioning of the cardiac implantable electrotherapy devices. In our case, we observed the lack of detection of heart activity and consequently pacing at sensing of 2 mV (Figure 1B).

Programming of pacemaker sensing determines its abiity to detect intrinsic cardiac electrical impulses. It makes heart stimuli with amplitude lower than programmed invisible to the pacemaker, that provides pacing. When the programmed sensing value is too low, not only heart activity can be detected but also other changes in the electrical field, not connected with the heart, which will stop stimulation.

The highest sensitivity value for proper detection and stimulation was 0.9 mV (Figure 1C).

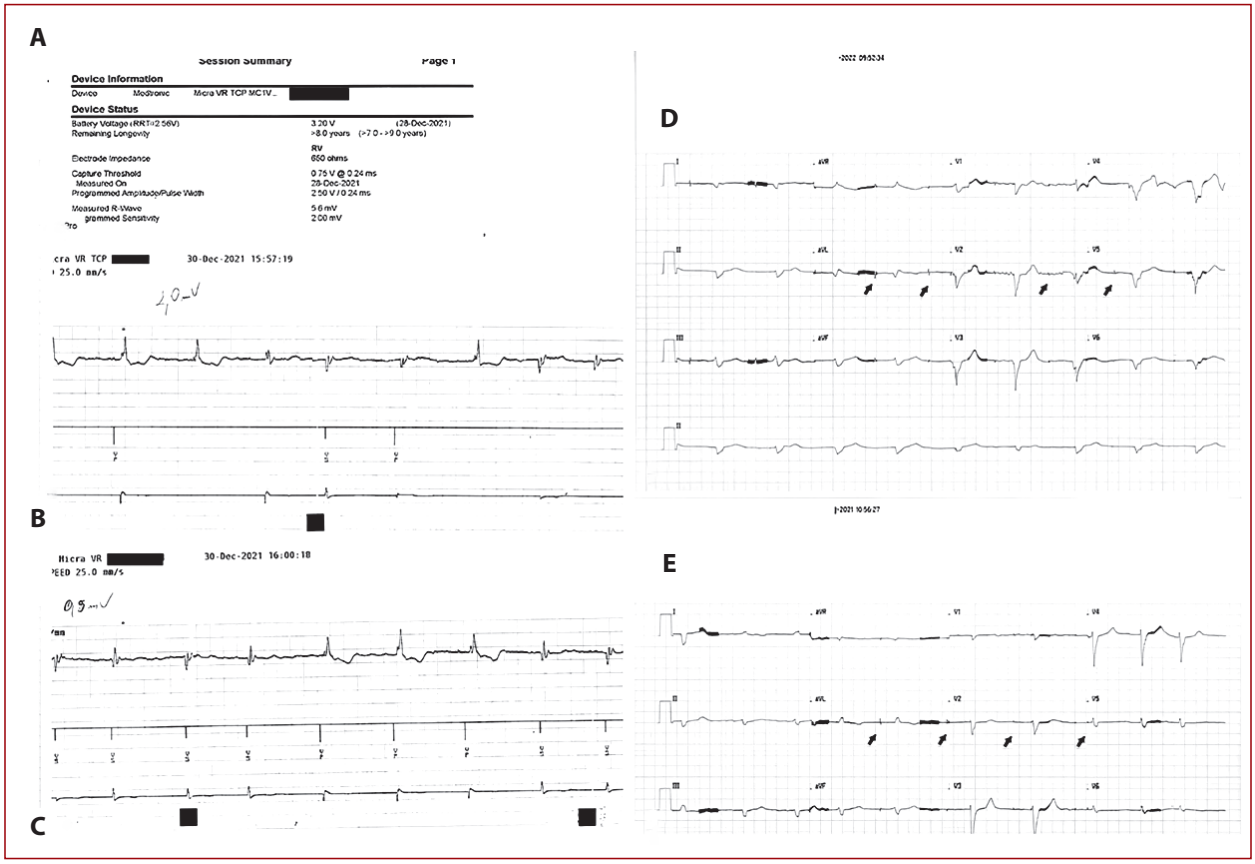

Figure 1. A. Implanted pacemaker settings directly after surgery. **B.** Lack of both detection of the intrinsic electrical activity of the heart and pacing (middle and third line) with sensing programmed at 2 mV. **C.** Correct detection and pacing with pacemaker's sensing programmed at 0.9 mV. **B.** 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 pacemaker implantation with the same fake spikes

The correct function of the pacemaker in that setting and recurrence of the abnormality after an increase in the sensitivity value was confirmed in 1-year follow-up, which suggests "under-sensing" caused by the electromagnetic field and no reaction of the pacemaker.

Another explanation can be a weak telemetry connection between the pacemaker and the controller, which also can affect the electromagnetic field and is partially dependent on the distance between the pacemaker and the LVAD, as previously reported [5].

Another problem with the electromagnetic field is proper interpretation of ECG records due to artifacts. Impellers of the HeartMate3 devices run with an oscillating frequency of 83.3–100 Hz while most ECG machines can register changes in the electric field within the 0.16–150 Hz range, which leads to recording part of the electromagnetic spectrum as 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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