End-of-service program compulsory ventricular pacing by the transvenous pacemaker remaining after implantation of a leadless pacemaker

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Introduction

Micra (Medtronic, Minneapolis, MN) is a leadless pacemaker implanted percutaneously through a transcatheter system1,2 and is an alternative form of ventricular pacing that may avoid the complications of traditional transvenous pacing systems.3 Compared with the traditional transvenous systems, Micra reportedly reduces the incidence of major complications by approximately 63%.4 Therefore, a leadless pacemaker is preferred for older patients with comorbidities who are at significantly increased risk of transvenous pacing systems complications.5

When battery depletion is detected in patients implanted with a transvenous pacemaker, the new technique of Micra implantation instead of battery replacement has emerged as an alternative strategy. However, whether the remaining transvenous pacemaker should be removed after Micra implantation is unclear.

Herein, we describe the case of a patient who underwent implantation of Micra instead of battery replacement; this patient experienced the end-of-service (EOS) program initiated by the remaining transvenous pacemaker and needed an emergency procedure to remove the old transvenous pacemaker.

Case report

An 85-year-old man visited our hospital to have the battery of his transvenous pacemaker (Identity A-DX 5350; Abbott [SJM], Abbott Park, Chicago, IL) replaced. He had previously undergone dual-chamber transvenous pacemaker implantation because of sick sinus syndrome 15 years prior.

Six years later, he had his first battery replacement. During device check, the pacemaker mode was changed from dual-chamber demand pacing (DDD) to ventricular-chamber demand pacing (VVI) because asymptomatic persistent atrial fibrillation had been detected. The pacemaker and ventricular lead parameters were set as follows: generator impedance, 10.8 kΩ; electromotive force, 2.71 V; lead impedance, 608 Ω; sensing voltage, 12.5 mV; pacing capture threshold, 0.75 V / 0.4 ms; and ventricular pacing rate, 10.7%. The patient was diagnosed with mild vascular dementia, hypertension, and chronic kidney disease (estimated glomerular filtration rate of 45 mL/min). He was prescribed warfarin and had a stable international normalized ratio.

We discussed a plan for battery replacement with the family members because the patient’s condition was complicated by dementia. We proposed that the leadless pacemaker implantation could be an alternative to battery replacement. The patient’s family members hoped that Micra implantation would be performed without explanting the old transvenous pacemaker system because the patient had severe pain from the pocket incision after the first battery replacement. In addition, there was a risk of postoperative pacemaker pocket infection or hematoma because the patient needed anticoagulant therapy even during surgery. Therefore, we decided...
to perform Micra implantation without removing the old transvenous pacemaker.

We successfully implanted Micra in the right ventricular mid-distal septum. The parameters of Micra were as follows: electrode impedance, 400 Ω; sensing voltage, 7.4 mV; and pacing capture threshold, 0.25 V / 0.05 ms. To avoid unnecessary pacing, the program of the remaining transvenous pacemaker was changed as follows: pacing mode VVI, 30 beats per minute (bpm); sensing threshold, 12.5 mV (maximum sensing threshold); and pacing output, 0.25 V / 0.05 ms (minimum pacing output).

At the 6-month follow-up, the patient was in a stable condition. No significant changes were found in the parameters in either Micra or the remaining transvenous pacemaker. However, at the 12-month follow-up, the electrocardiogram showed an unexpected incessant pacing spike under unstable ventricle undersensing (Figure 1). Notably, 1 of the pacing spikes captured the ventricular myocardium. The parameters of Micra were stable, and were as follows: pacing mode VVI, 40 bpm; electromotive force, 3.05 V; electrode impedance, 440 Ω; sensing voltage, 10.1 mV; pacing capture threshold, 1.75 V / 0.24 ms; and pacing output, 2.38 V / 0.24 ms. Examination of the old transvenous pacemaker was not possible because the program had already entered the EOS. Based on the QRS morphology after the unexpected spike, the recorded pacing spike was assumed to originate from the remaining transvenous pacemaker. We speculated that the EOS automatically launched the EOS program and delivered compulsory pacing. Emergency surgery was performed to remove the transvenous pacemaker because there was a high risk of developing a lethal ventricular tachyarrhythmia owing to uncontrolled ventricular pacing. The analysis of the explanted pacemaker was performed by an oscilloscope, which revealed a pacing rate of 67.5 bpm and pacing output of 5.0 V / 0.6 ms on unipolar pacing (Supplementary Video). The patient was discharged and remained stable in the outpatient clinic.

Discussion

We present a case of unexpected compulsory ventricular pacing from a nonexplanted transvenous pacemaker after Micra implantation. There was an urgent need to remove the old transvenous pacemaker in the present case.

Recently, Micra was developed to avoid complications of traditional transvenous pacing systems.1,2 Micra is a single-chamber pacemaker, and there is limited clinical research data about the feasibility and safety of the long-term implantation of Micra6; therefore, older patients with symptomatic bradycardiac atrial fibrillation are good candidates for Micra implantation. Older patients are likely to have many comorbidities, such as atrial fibrillation and dementia. Older patients with atrial fibrillation often require permanent anticoagulant therapy, thereby posing risks of complications during invasive clinical procedures.7 Based on this background, Micra implantation, instead of replacement of the transvenous pacemaker battery, has emerged as an alternative option in patients receiving implantation of transvenous pacemakers and requiring battery replacement. However, it remains to be elucidated whether the old transvenous pacemaker needs to be removed after Micra implantation.

All settings in the transvenous pacemaker could not be completely turned off. When the transvenous pacemaker faces severe battery depletion, the EOS program, which
cannot be programmed automatically, initiates. The detailed settings of the EOS program vary among each device manufacturer (Table 1). The EOS program makes ventricular pacing a top priority and minimizes power consumption; therefore, device telemetry interrogation for certain devices becomes unavailable. To our knowledge, there is no program, including a sensing program like ODO mode, that could prevent the EOS programming. During the EOS program, the pacing mode is always VVI or ventricular-chamber compulsory pacing (VOO). In this case, the analysis of the explanted pacemaker using the oscilloscope revealed that the pacing mode was VVI with unipolar 5.0 V / 0.6 ms pacing and unstable sensing. We could not identify the detailed sensing threshold because device telemetry interrogation was unavailable during the EOS program. As in our case, the EOS program could automatically deliver compulsory ventricular pacing and might induce lethal ventricular tachyarrhythmias. We needed to explant the pacemaker operating in the EOS program, which automatically initiated compulsory ventricular pacing.

An EOS program is used not only in pacemakers but also in other cardiac implantable electronic devices such as implantable cardioverter-defibrillators (ICDs). Recently, the deactivation of ICD therapies has been debated in older patients and those with end-stage heart failure. The indications for ICD implantation can change over time. When ICD battery replacement is needed, some patients, especially those with a terminal illness, may no longer want to undergo such a replacement procedure. They may wish to turn off the ICD function completely without the explant of the ICD. The deactivation of tachyarrhythmia therapies (shock delivery or antitachycardia pacing) is programmable. However, it is not possible to completely discontinue therapies for bradycardia. It could be necessary to inform patients and their family members of the risks of not undergoing ICD explant, as the EOS program might cause unpredictable errors.

**Conclusion**

The new technique of Micra implantation instead of replacement of the transvenous pacemaker battery is an alternative option for patients implanted with transvenous pacemakers who require battery replacement. Thus, we must check the model of the implanted pacemaker in detail, including the EOS program, and decide whether the implanted transvenous pacemaker should be explanted.

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**Appendix**

**Supplementary data**

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2022.07.008.

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**Table 1** Characteristics of pacemaker programs at the end of service according to each manufacturer

| Manufacturer       | Telemetry | Pacing mode | Lower rate | Sensing output | Sensing polarity |
|--------------------|-----------|-------------|------------|----------------|------------------|
| Abbott             | Unavailable | VVI        | 67.5 bpm   | 5.0 V / 0.6 ms | Unipolar         |
| Biotronik          | Available, but unstable | VVI⇒VDD VVI⇒VVI | Down by 4.5%–11% from baseline settings | Unstable | Unstable |
| Boston Scientific  | Available, but unstable VVI | 50 bpm | Unstable | Same as baseline settings | Unstable |
| Medtronic          | Available, but not programmable VVI | 65 bpm | Unstable | Same as baseline settings | Unstable |
| MicroPort          | Unavailable | VOO | 70 bpm | Unstable | Unipolar |

bpm = beats per minute; DDD = dual-chamber demand pacing; VDD = ventricular-chamber, dual-chamber demand pacing; VOO = ventricular-chamber compulsory pacing; VVI = ventricular-chamber demand pacing.