

Two-directional snare technique to rescue detaching leadless pacemaker



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Introduction

Dislodgment is a rare but severe complication of leadless pacemaker systems that requires immediate retraction. Although the majority of such cases are reportedly diagnosed and treated in a stable condition, whereby a dislodged device stays in the same position, dislodgment can also manifest in an unstable “cliffhanger” condition whereby an affected device is merely attached to the heart over 1 tine, thus causing it to sway. Little is known about how to safely retract a device that has become partially detached in such circumstances.

Case report

A 78-year-old man was referred to our hospital for suspected cardiac device-related infective endocarditis (CDRIE). Nine years previously, he had been implanted with a DDD pacemaker for bradycardia-tachycardia syndrome, which subsequently became chronic atrial fibrillation with a slow ventricular response. The patient had undergone a generator exchange 6 months before referral, then was diagnosed with the remitting seronegative symmetrical synovitis with pitting edema, for which oral prednisolone was introduced. The generator pocket swelled and septic matter subsequently emerged from the open wound a few months afterward. Transesophageal echocardiography revealed a 4-mm vegetation attached to the right ventricular (RV) lead, and pus culture was returned positive for methicillin-sensitive *Staphylococcus aureus*. These findings confirmed the diagnosis of CDRIE, which was treated by complete device removal, including extraction of leads. Based on the history of CDRIE and steroid use, we concluded that the leadless pacemaker system was preferred as a new device.

KEYWORDS Incomplete dislodgment; Leadless pacemaker; Micra; Retrieval; Two-directional snare technique
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KEY TEACHING POINTS

- “Incomplete” dislodgment of leadless pacemaker is life-threatening and requires an immediate rescue.
- Owing to a design flaw, it was difficult to catch the swaying device with the single-snare technique in the beating right ventricle. “Two-directional snare technique” via inferior vena cava and superior vena cava was vital to retrieve the wobbling leadless device.
- As the leadless implantable devices are expected to expand their use and thus build a bigger ecosystem, design of future leadless implantable devices should take the “retractability” into account for patient safety.

The entire infected system was removed using an excimer laser system (GlideLight Laser Sheath and CVX-300-P Excimer laser system; Spectranetics, Colorado Springs, CO) and a temporary pacing electrode was inserted via the right jugular vein. Following several weeks of standard antibiotic treatment with cephalosporin, a leadless VVI pacemaker (Micra; Medtronic, Minneapolis, MN) was implanted. At the initial attempt, around the mid-RV septum it was challenging to find a location with satisfactory stimulation and sensing parameters. The Micra was then deployed to the RV apex, where parameters were considered acceptable with a pacing threshold of 1.0 V at 0.24 ms and pacing impedance of 550 ohm. During the standard pull-and-hold test, at least 2 tines appeared to be fixed to the RV myocardium. The rest of the implantation procedure was uneventful.

Several hours after the surgery, pacing failure was noticed on 3.5 V at 0.40 ms. An immediate interrogation indicated that pacing threshold rose to 2.5 V at 0.40 ms, but chest radiography did not reveal obvious dislodgment. Output was raised to 5.0 V at 0.40 ms. Pacing failure did not recur overnight. The next morning, upon his sitting up on the bed after bed rest, the patient suddenly developed palpitation

and lightheadedness, followed by multiple monomorphic nonsustained ventricular tachycardias. A repeated device interrogation confirmed both pacing failure at 5.0 V/1.0 ms, increased pacing impedance of 850 ohm, and sensing failure (missed R waves at 2.0 mV). An echocardiogram revealed a partially dislodged Micra appearing to twirl in the right ventricle. The Micra was swaying with the hyperkinetic tail pivoting around the head, which apparently remained attached to the RV wall via only 1 tine ([Supplemental Movie 1](#)). Imminent dislodgment was diagnosed, for which urgent retrieval was warranted.

The 23F Micra Introducer (Medtronic) and a 9F sheath were placed in the inferior vena cava (IVC) via the right femoral vein and in the superior vena cava (SVC) via the right internal jugular vein, respectively. An 8.5F medium-curve steerable sheath (Agilis NxT; St Jude Medical, St Paul, MN) via the Micra sheath in the IVC and an 8F SL-1 long sheath (Swart Braided Transseptal Guiding Introducer; St Jude Medical) via the 9F sheath in the SVC were advanced to the right atrium. At first, we placed a 20-mm multi-loop snare (EN Snare; Merit Medical Systems, South Jordan, UT) from the SVC to the RV outflow tract for distal protection in case the Micra completely dislodged, and a 25-mm single-loop snare (Amplatz GooseNeck Snare; Covidien/Medtronic, Minneapolis, MN) via the IVC to capture the retrieval head of the Micra ([Figure 1](#)). We found that the Micra body could be captured by a single-loop snare, but it was extremely challenging to catch the retrieval head using only 1 snare because the Micra was constantly wobbling and unstable. We thus changed the multiple-loop snare from the SVC to a 25-mm single-loop snare, which was used to attempt to minimize Micra movement by capturing its tines. In addition,

we used a 15-mm single-loop snare (Amplatz GooseNeck Snare; Covidien/Medtronic) from the IVC because a smaller-looped snare was considered optimal for capturing the small retrieval head. With its movement abated by the snare from the SVC, the body of the Micra was captured by the snare from the IVC ([Figure 2](#)) and was pulled away safely from the myocardium while being held by the 2 snares. Having considered it to be still difficult and unsafe to capture the retrieval head in the beating right ventricle where the blood flow and wall motion were unsteady, we moved the Micra to the IVC and captured its retrieval head with the snare from the IVC ([Supplemental Movie 2](#)). With the snares from both SVC and IVC pulled together, the device was positioned coaxially to the 23F introducer sheath. The Micra was then retracted into the sheath and subsequently extracted from the patient's body.

Given the limited viable options in the locations of RV myocardium with desirable pacing parameters, and the fact that the dislodgment occurred from the best possible location we chose in the initial implantation, we decided not to reuse the detached Micra. Instead, immediately after the retrieval, a transvenous pacemaker was implanted from the opposite side of the infectious wound. The patient was discharged after a week and now visits our hospital regularly, without further complaints.

Discussion

“Incomplete” dislodgment of leadless pacemaker

This is the first report of the “incomplete” dislodgment of a Micra leadless pacemaker system and its successful rescue by a novel 2-directional snare technique via IVC and SVC. This form of incomplete “cliffhanger” dislodgment is unique

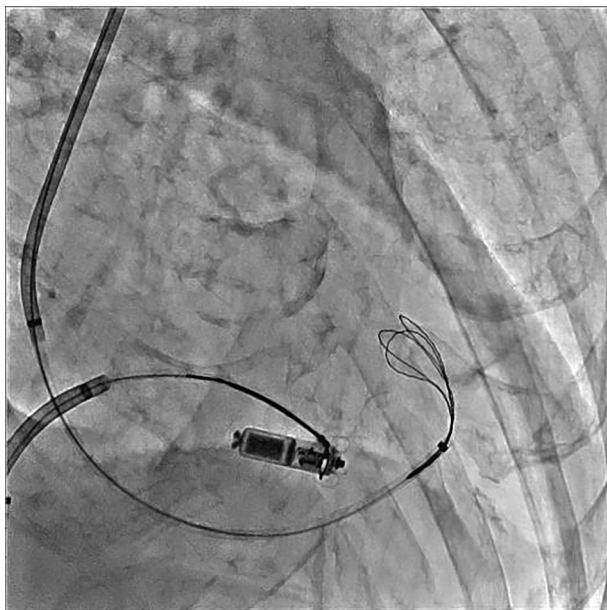


Figure 1 A 20-mm multi-loop snare from superior vena cava at right ventricle outflow tract for distal protection and a 25-mm single-loop snare via inferior vena cava for trying to capture the retrieval head of the Micra pacemaker (Medtronic, Minneapolis, MN).

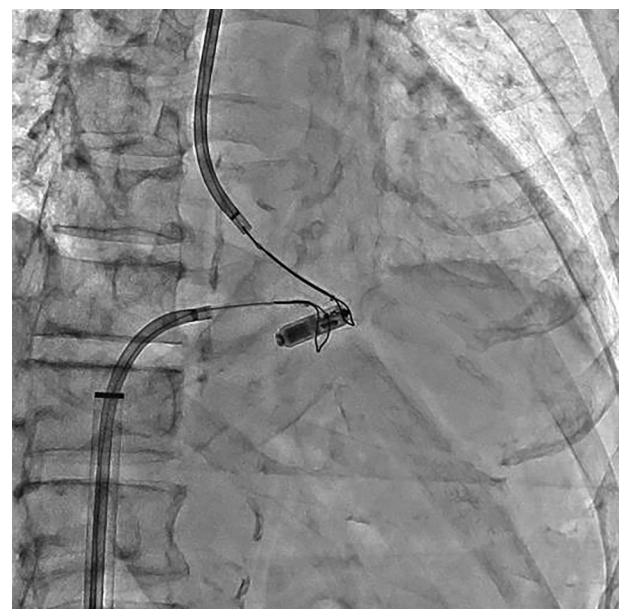


Figure 2 With its tines being captured and its movement abated by a snare from the superior vena cava, the Micra pacemaker (Medtronic, Minneapolis, MN) was captured by a snare from the inferior vena cava.

to the leadless pacemaker system. Multiple factors such as its small-sized design, lack of a dedicated retrieval system, the vigorous motion, and intracardiac structures including papillary muscle hampered the rescue attempt.

Dislodgment is a rare but potentially fatal complication in a leadless pacemaker system. The Micra Post-Approval Registry, which analyzed 795 patients, reported a dislodgment rate of 0.13% through 30 days after implantation.¹ For those for whom leadless VVI pacemaker system is indicated, the device dislodgment can lead to catastrophic pacing loss, which may cause syncope and death. The device embolism to the pulmonary artery is another possibly fatal consequence. Therefore, dislodgment requires emergent removal and stabilization. The majority of previously reported dislodgment is “complete,” whereby the detached device was found in a remote location such as the pulmonary artery, or “micro” dislodgment, whereby an elevated pacing threshold without obvious dislocation was noted. In such circumstances, the detached devices are stationary. By contrast, the present case represents “incomplete” dislodgment, characterized by vigorous movement in the right ventricle resembling a “cliff-hanger” rotation around the last attached tine. As demonstrated in this case, the vigorous movement can result in multiform and frequent nonsustained ventricular tachycardia, an additional indication for urgent Micra retrieval in addition to pacing failure. Other potential hazardous risks of this gyrating action include damages to chorda tendinea, papillary muscle, and RV myocardium and subsequent complete dislodgment. Therefore, we believe that this unstable condition should also require immediate attention and stabilization.

An acute deterioration in pacing parameters (eg, threshold, sensitivity, and impedance) can be an initial presentation of this rare condition. Although the impedance increased a little, it did not necessarily mean the strong attachment of the device in this case, probably because the distance between the anode of the device and myocardium at the time of measurement happened to be closer than that of the pre-dislodgment. Therefore, unstable impedance by the repeated measurement could suggest the insecure connection between the device and heart, which warrants further diagnostic examinations.

Two-directional snare technique for retrieval of Micra in an unstable condition

In this case, we demonstrated the usefulness of the 2 single-loop snares technique, whereby 2 operators operate 2 snares inserted from the SVC and IVC, respectively. We believe that this approach is a reasonable option when the conventional 1-snare technique^{2,3} falls short. Indeed, a few case reports have demonstrated that 2 or 3 snares from the IVC are effective for the rescue of a Micra completely dislodged to the pulmonary artery or right ventricle.^{4,5} A 2-directional approach via the IVC and SVC may be easier to operate in some circumstances, as they do not interfere with each other and offer advantages, particularly when the device is in an unstable state.

Retrieval of a Micra device moving in an unstable manner can be summarized in the following 3 steps:

- (1) Catch: The SVC snare holds the Micra to minimize movement while the IVC snare attempts to capture the body.
- (2) Hold: Using 1 snare as a backup minimizes the risk of dropping the Micra and assists in bringing it to the IVC safely. While the SVC snare holds the Micra, the IVC snare can capture the retrieval head.
- (3) Pull: With the captured Micra positioned coaxially to the delivery sheath while being held by IVC and SVC snares, it can be safely retracted when withdrawn into the sheath.

This 2-directional snare technique via the IVC and SVC is a useful retrieval method for a Micra with unstable movement, such as when incompletely dislodged.

Micra dislodgment: Areas for improvement

In the present report we demonstrate a novel retrieval technique as a rescue procedure, but there seem to be several other areas for improvement regarding Micra dislodgment. These may be divided into 4 categories according to 2 points of view. One viewpoint concerns aspect (device or procedural) and the other applies to purpose (prevention or rescue) ([Supplementary Figure](#)).

First, regarding aspects of the device, to prevent dislodgment more objective evaluation of the stability of the fixed Micra is desirable. The Micra has a passive fixation mechanism using tines to fix it to the myocardium. The only way to confirm the fixation is the pull-and-hold test, which almost always depends on subjective judgment.

Second, at rescue for dislodgment, no dedicated retrieval system for the Micra is currently available. Nanostim (St Jude Medical), another leadless pacemaker, has its own retrieval catheter system whose safety and efficacy has already been reported.⁶ For extraction of the Micra, at present we have to use the delivery system as the retrieval system. Therefore a genuine retrieval system must be developed and evaluated, thus leading to a unified standard retrieval method. Another desirable improvement lies in the design of a retrieval system. The retrieval head of an unstable Micra is difficult to capture with a snare because the head is too small; therefore, the next-generation system should be redesigned appropriately to accommodate size anomalies.

For prevention of dislodgment, we may have to confirm the fixation of at least 3 tines at implantation. In the present case, although we evaluated fixation of at least 2 tines by the pull-and-hold test, which is acceptable for Micra implantation at present, this Micra partially dislodged, resulting in urgent retrieval. Only 1 device dislodgment was noted in the Micra Post-Approval Registry, which also involved only 2 tines embedded in myocardial tissue.¹ It is not difficult to surmise that fewer tine fixations may lead to an unstable outcome.

Even if new retrieval systems and prevention methods are developed, clinicians will have to master and develop retrieval techniques.

Leadless pacemaker is becoming a viable option for patients at high risk of transvenous leads and pocket-related complications.⁷ Furthermore, looking to the future, a leadless device-to-device communicating system has been under development. Future concepts include communication with a transvenous pacemaker, a subcutaneous implantable cardioverter-defibrillator, and leadless pacemakers in multiple sites (eg, the right atrium, right ventricle, and left ventricle). This expanded device network will orchestrate the complex nonpharmacological therapies such as cardiac resynchronization therapy, defibrillation, and constant monitoring of pulmonary artery pressure, which should be of interest in the field of heart failure.⁸

As the leadless pacemaker has become a major therapeutic option as a pacing system and the core device for expanded leadless communicating systems, novel retrieval techniques and ongoing improvements are important fundamentals in the development of cardiac devices.

Conclusion

A 2-directional snare technique using snares from the SVC and IVC demonstrated practicality in treating unstable dislodgment of a leadless pacemaker.

Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://10.1016/j.hrcr.2020.06.027>.

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