Usefulness of the Snare Technique During Leadless Pacemaker Implantation for a Patient with a Severely Dilated Right Atrium
A Case Report

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Summary
We report here the case of a 92-year-old woman with atrial fibrillation bradycardia in which leadless pacemaker implantation was performed with a difficult delivery of the catheter sheath due to an extremely large right atrium. Using a snare technique with correction of the direction of the force on the catheter toward the right ventricle (RV) can result in successful delivery of the pacemaker catheter and stable placement of the pacemaker system in the RV septum. This specific snare technique has the potential to facilitate leadless pacemaker implantation safely in a severely dilated chamber of the heart, making this technique effective to use in clinical practice.

Key words: Atrial fibrillation, Gooseneck

Leadless pacemaker implantation has been developed as a useful therapeutic option for patients requiring permanent single-chamber ventricular pacing.1,2 Leadless pacemakers can reduce the rate of procedural complications by 63% compared to that of traditional pacemakers.3 Therefore, leadless pacemakers have sometimes been used as alternatives to transvenous pacemakers, especially in elderly patients and patients with chronic atrial fibrillation (AF) with bradycardia because they allow for a less invasive procedure, better infection control, and avoidance of vascular problems.4 However, there are anatomical limitations that make leadless pacemaker implantations difficult on some occasions. The leadless pacemaker system is composed of a thick catheter sheath and an inner packaged pacemaker that allows for limited manipulation, making the implantation procedure difficult in the presence of a tortuous vessel or a shifted or dilated cardiac chamber.

Herein, we describe a case in which leadless pacemaker implantation was performed with a difficult delivery of the catheter sheath due to an extremely large right atrium (RA). Using a snare technique resulted in successful access to the right ventricle (RV) and safe implantation of the pacemaker system.

Case Report
A 92-year-old woman visited the emergency department of Yokkaichi Municipal Hospital complaining of fatigue and dizziness. She had a history of permanent AF and dementia. A 12-lead electrocardiogram showed a long pause of more than 4 seconds and AF. A chest radiograph showed severe cardiac enlargement with a cardiothoracic ratio of 92% (Figure 1A). Transthoracic echocardiography revealed a large dilated RA and severe tricuspid regurgitation (Figure 1B). To treat the symptomatic AF with bradycardia, emergency cardiac pacing was attempted by inserting a temporary transvenous pacemaker lead via the right internal jugular vein. However, the pacemaker lead failed to reach the RV due to the prominent and enlarged RA. In view of the patient’s condition, after considering the advantages and disadvantages of leadless pacemakers in comparison to those of conventional transvenous pacemakers, such as a shorter procedure time, pocket infection exposure, and post-operative bed rest, only requiring ventricular pacing, vascular complications during insertion of the thick sheath, and difficulty with manipulation of a thick catheter that can result in severe complications, we decided to perform a leadless pacemaker implantation (Micra, Medtronic, Inc., Minneapolis, MN) after obtaining informed consent from the patient and her family.5

Implantation was performed under the guidance of fluoroscopy and transthoracic echocardiography. A leadless pacemaker system was inserted through the right femoral vein via a 27-Fr introducer sheath (Medtronic, Inc., MN, USA). Angiography was performed to identify...
Figure 1. A: Chest X-ray showing a cardiothoracic ratio of 92%. B: Transthoracic echocardiography showing a dilated right atrium and severe tricuspid regurgitation prior to pacemaker implantation. Volume of the right atrium was 535 mL. The longitudinal and transverse diameters of the RA on echocardiography were 11.4 cm and 8.5 cm, respectively.

Figure 2. A radiograph showing the conventional method of leadless pacemaker implantation in a dilated heart. The pacemaker was unable to reach the right ventricle because of the severely dilated right atrium. Red arrow shows the direction of the sheath’s movement when it is pushed. The orange dotted line indicates the tricuspid valve.

The size of the RA and tricuspid valve position, following which we attempted to deliver the leadless pacemaker to the RV using the conventional method. However, the leadless pacemaker could not reach the RV even after applying pressure and attempting a clockwise rotation of the catheter due to the severely dilated RA. The operator pushed the pacemaker system, but the force of the push diverted the catheter in the direction of the upper part of the RA (Figure 2). Thus, a triple loop snare catheter (EN Snare, Merit Medical Inc., Salt Lake City, UT, USA) was used to correct the direction of the pacemaker catheter coaxially toward the RV. The snare comprised 3 loops combined as one, and the diameter of the entire loop ranged from 27 mm to 45 mm. The snare catheter was inserted from the left femoral vein by an assistant doctor. First, the pacemaker’s steerable sheath system was pulled down to the inferior vena cava and hooked by the snare ring (Figure 3A). Second, the pacemaker catheter was bent with the handle while approaching the tricuspid valve and the sheath was snared distal to the point where it bent. We then advanced the pacemaker sheath system into the RV while the snare was continuously held and pulled to prevent the diversion of the catheter toward the upper RA. Subsequently, the pacemaker was smoothly inserted into the RV using the snare technique (Figure 3B). Thereafter, the pacemaker was turned toward the RV septum by clockwise rotation. After confirming that the sheath was facing the RV septum, we attempted to position the catheter sheath in a gooseneck shape by maintaining the pull on the snare; however, the force of the pull could not adequately transfer to the distal side of the catheter. Conversely, the distal side of the catheter was pulled back, creating a distance between the catheter and the RV myocardium (Figure 3C). To avoid collapse and dislodgement of the system, we pushed and deployed the pacemaker at the RV septum without creating an adequate gooseneck position. After this first attempt, the pacemaker was implanted in the lower septum of the RV (Figure 3D). The pull-and-hold test was performed to confirm seating of 3 tines. The pacemaker parameters post-implantation were an R-wave sensing amplitude of 8.7 mV, impedance of 590 Ω, and pacing threshold of 2.13 V/0.24 ms (1.88 V/0.4 ms). Although the pacing threshold was relatively high in this case, this was tolerable considering the minimum requirement of the back-up pacing for the intermittent pause of the AF bradycardia and the advanced age of the
SNARE TECHNIQUE IN LEADLESS PACEMAKER IMPLANTATION

Figure 3. Fluoroscopic images during the snare technique facilitating the leadless pacemaker implantation through a severely dilated right atrium. All images are presented in the right anterior oblique view at 30°. The white arrow indicates the snare. The orange dotted line indicates the tricuspid valve. A: A triple-loop snare caught the shaft of the leadless pacemaker system in the inferior vena cava. B: The leadless pacemaker is inserted smoothly into the right ventricle by pulling the snare continuously. C: The gooseneck shape of the catheter by pulling the snare. However, this gooseneck shape caused the distal part of the catheter to be pulled down, leading to an incomplete apposition between the catheter and myocardium. D: Pacemaker implantation achieved while holding the snare.

Discussion

In this study, we report the usefulness of a snare technique during leadless pacemaker implantation in a patient with a severely dilated RA. Correcting the direction of the force on the catheter by pulling the snare toward the RV can result in successful delivery of the pacemaker catheter and stable placement of the pacemaker system in the RV septum.

Similar to transvenous pacemaker implantation, leadless pacemaker implantation is expected to be difficult in patients with a dilated RA and RV. This is because the pacemaker system cannot reach the RV when the radius of the RA is larger than the maximum radius that the catheter was designed to pass through. The manipulation of the thick catheter is also limited with a difficulty of the application of delicate and small adjustments. Moreover, the pushing force is unlikely to affect the distal part of the catheter, even if the system passes the tricuspid valve and reaches the RV. In our case, the pushing force applied on the catheter diverted it toward the upper part of the RA, not coaxially toward the RV. Despite being aware of the above-mentioned concerns, we elected to implant a leadless pacemaker instead of a conventional transvenous pacemaker. This decision was likely to have more advantages than disadvantages considering the patient’s advanced age, history of permanent AF, the need for only ventricular pacing, prevention of bleeding and pockets of infection, and dementia. Furthermore, there was a lower risk of damaging the tricuspid valve and progression of tricuspid regurgitation after leadless pacemaker implantation compared to using a transvenous pacemaker. Pagan,
et al.\textsuperscript{6,9} reported that leadless pacemaker implantation in the very elderly was safe and resulted in a significantly shorter procedure time as compared to transfemoral pacemaker implantation. Shorter procedure times are desirable in the management of the elderly and those with dementia, making these patients good candidates for leadless pacemaker implantation.

We found that using the snare technique to assist leadless pacemaker implantation has several advantages in the case of a patient with a dilated RA. First, pulling the snare can prevent the catheter sheath from turning unexpectedly toward the upper RA and applying a pushing force can coaxially direct the catheter toward the RV. Numerous repetitive attempts to carry the catheter sheath into the RV using the conventional approach may lead to a risk of cardiac injury and complications. These risks were avoided in our case by using the snare technique, which allowed for the pacemaker to be inserted in the RV in a short period of time. Furthermore, the use of a snare provided adequate fixation without the catheter sheath slipping out even after its insertion into the RV. However, it is difficult to know how much cup pressure is applied when a snare holds the shaft. A high cup pressure increases the risk of major complications. We tried to position the catheter sheath as a gooseneck shape by pulling on the snare more strongly. Conversely, the distal side of the catheter was pulled back, creating a distance between the catheter and the RV myocardium. Careful attention should be paid and a balanced force should be applied while pulling the snare; furthermore, pushing the catheter should be done by the operator and the assistant together in order to avoid complications when using this technique. Although we did not achieve an adequate gooseneck position of the catheter in our case, the degree of pressure on the sheath and force against the RV septum were adjustable by simultaneously holding and pulling the snare.

A few reports have demonstrated leadless pacemaker implantation using the snare technique.\textsuperscript{\textbullet,7,8} Alyesh, \textit{et al.}\textsuperscript{7} recently reported the use of the snare technique to implant a leadless pacemaker in a patient with a dilated atrium. They used double snare wires inserted through the same sheath as the leadless pacemaker; however, the insertion of another device through the same sheath poses a possible risk of backflow of blood through the sheath. Contrary to the method used by Alyesh, \textit{et al.}, we selected the opposite site of the left femoral vein to insert the snare catheter in order to avoid perioperative anemia in patients with heart failure. Huang, \textit{et al.}\textsuperscript{8} also reported the use of the snare technique in a patient with breast cancer and a dilated RA after the extraction of a permanent transfemoral pacemaker. They inserted a snare from the opposite femoral vein, similar to the procedure we performed; however, they used a snare with a single ring, which might require a greater amount of force when pulling the catheter sheath down during the insertion process, risking damage to the delivery catheter. In contrast, the snare used in our case had multiple rings that held the catheter sufficiently at multiple points, transferring the force applied on the snare onto the catheter. This resulted in the successful correction of the direction of the delivery catheter without causing it any damage. Considering its ability to avoid the above-mentioned risks, the specific snare technique reported in this case has the potential to facilitate leadless pacemaker implantation safely in a severely dilated chamber of the heart, making this technique effective to use in clinical practice.

\section*{Conclusion}

The snare technique during the implantation of a leadless pacemaker in patients with large right atria could be useful and safe.

\section*{Disclosure}

\textbf{Conflicts of interest:} The authors declare that they have no conflict of interest.

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