

Remote magnetic navigation–guided ventricular tachycardia ablation with continuous-flow mechanical circulatory support



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Introduction

Catheter ablation (CA) is an important treatment option for patients with ischemic heart disease presenting with ventricular tachycardia (VT).^{1,2} Various CA techniques are currently available, including remote magnetic navigation (RMN)–guided ablation.² Most published studies reported superiority of RMN-guided VT ablation over manual ablation, with respect to acute success, recurrence, procedure time, fluoroscopy time, and complications.^{3–5} The RMN system (Niobe Epoch, Stereotaxis Inc, St. Louis, MO) uses 2 permanent magnets mounted on pivoting arms, 1 magnet on either side of the patient, which creates a computer-controlled steerable magnetic field to remotely guide the movement of a magnetically enabled ablation catheter.⁶

Unfortunately, many VTs are not suitable for mapping during VT ablation, mostly because of their hemodynamic instability.⁷ It is well known that hemodynamically unstable VT might be successfully ablated with the aid of mechanical circulatory support (MCS), using a variety of devices.^{8–10} However, most of the currently available continuous-flow MCS devices operate using a metal pump as core of the technology, which limits their use in a magnetic environment. The risk of electromagnetic interference has resulted in restraint in the use of percutaneous continuous-flow MCS during RMN-guided VT ablation.^{11,12} This would be a major limitation, especially in centers with a preference for RMN-guided VT ablation. For the first time, we report a case in which, with careful planning, RMN-guided VT ablation was successfully combined with hemodynamic support using the Impella continuous-flow MCS (Abiomed Inc, Danvers, MA).

KEYWORDS Catheter ablation; Continuous-flow mechanical circulatory support; Mechanical circulatory support; Remote magnetic navigation; Robotic navigation; Ventricular tachycardia
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Case report

A 67-year-old man with a past medical history of coronary artery disease causing ischemic cardiomyopathy was admitted to our hospital because of recurrent VTs. In 2006, the patient had undergone a successful resuscitation after ventricular fibrillation caused by an acute anterior myocardial infarction. Rescue percutaneous intervention of the left anterior descending coronary artery was performed. Chronic total occlusion of the mid right coronary artery was noted. The distal right coronary system was supplied by collateral circulation from the left anterior descending coronary artery. In 2008, the patient was readmitted with myocardial infarction due to stent occlusion. Left ventricular (LV) function was poor (LV ejection fraction 16%). Magnetic resonance imaging showed a transmural anterior infarction. A VVI implantable cardioverter–defibrillator (ICD) was inserted for secondary prevention. The ICD was upgraded to a cardiac resynchronization therapy-ICD in 2018 because of progressive heart failure.

In 2016, the patient developed slow VTs, which had a cycle length under the programmed detection zone of the ICD. These VTs caused rapid hemodynamic deterioration requiring immediate basic life support. Medical treatment with amiodarone was started. The patient did not experience recurrences until 2018, when he was admitted again with slow VTs causing rapid hemodynamic deterioration. A manually guided VT ablation (NaviStar SmartTouch D-curve catheter, Biosense Webster, Diamond Bar, CA) was undertaken. The ablation procedure could not be completed because of difficulty in maneuvering in the extremely dilated LV and frequent spontaneous induction of unstable VTs during mapping that caused severe hemodynamic deterioration. A repeat procedure with hemodynamic support was proposed. However, because of the difficulties encountered during the first ablation attempt, the operator could not prioritize between RMN-guided ablation to facilitate maneuvering and hemodynamic support by continuous-flow MCS. The patient provided written informed consent for the procedure as well as presentation of his medical history.

KEY TEACHING POINTS

- Hemodynamic support by the Impella continuous-flow mechanical circulatory support device (Abiomed Inc, Danvers, MA) seems to be compatible with remote magnetic navigation-guided ablation and did not result in electromagnetic interference.
- To prevent electromagnetic interference of the Impella with the strong magnetic fields used in remote magnetic navigation-guided ablation, we advise careful positioning of materials as well as starting the Impella before activating the magnets.
- Precautionary use of the manual mode on the Impella instead of the automatic mode is recommended during remote magnetic navigation-guided ablation.

RMN-guided VT ablation with hemodynamic support

In July 2018, VT ablation was scheduled with hemodynamic support using a continuous-flow MCS device in combination with RMN. The procedure was performed with the patient under local anesthesia. The left and right femoral arteries and veins were punctured. A 5F sheath was introduced in the left femoral artery for hemodynamic monitoring. The Impella CP percutaneous continuous-flow MCS was inserted via a 14F sheath in the right femoral artery, crossing the aortic valve. A quadripolar catheter and intracardiac echocardiographic transducer were inserted in the right ventricular apex and right atrium, respectively. After the MCS was activated, programmed ventricular stimulation resulted in fast VTs that were not mappable. Mean arterial pressure (MAP) remained adequate with help of the MCS. Next, intracardiac echocardiography-guided transseptal puncture was performed using an 8.5F SL1 sheath. After transseptal puncture, a bipolar voltage map of the LV was created using the CARTO 3-dimensional electroanatomic mapping system (Biosense Webster) together with the RMN system and the NaviStar RMT ThermoCool ablation catheter (Biosense Webster). After a very dense voltage map was completed, scar homogenization was performed using the following radiofrequency settings: continuous ablation with 50 W, 43°C, flow 20 mL/min. Because of MCS, it was hemodynamically well tolerated to ablate during VT for >35 minutes in total (Figure 1). The mapping and ablation were performed using a NaviStar RMT ThermoCool catheter. The very extensive anterior scar became unexcitable, as proven by pacing maneuvers. Only (nonclinical) fast VTs and ventricular fibrillation were inducible after ablation and were well tolerated because of the continuous-flow MCS. Total procedure time was 354 minutes, total fluoroscopy time 27 minutes, and total ablation time 2971 seconds. Continuous rhythm observation

during 48 hours postprocedure showed no VT recurrences. Kidney function remained stable (CKD-EPI [Chronic Kidney Disease Epidemiology Collaboration] estimated glomerular filtration rate 51 mL/min preprocedure, 45 mL/min postprocedure). The patient was discharged home the second day after the procedure.

Procedural precautionary measures

Preprocedure, several precautionary measures were taken to safely combine the Impella continuous-flow MCS with RMN-guided ablation. Preprocedure, a step-by-step procedural approach was designed by the electrophysiologist, interventional cardiologist, and operating team, along with technical support from engineers from Abiomed and Stereotaxis. At the start of the procedure, CARTO patches (Biosense Webster) were positioned carefully on the chest and back of the patient, with the Impella motor lying as far out of their field as possible to prevent EMI (Figure 2). Subsequently, the Automated Impella Controller (AIC) module, the Impella user control interface, was positioned carefully outside the magnetic field (5-Gauss zone). The continuous-flow MCS was positioned and activated before the RMN magnets were put in navigate position to prevent eventual motor stop. The flow rate of the Impella can be adjusted by performance levels (P-levels), corresponding to a fixed rate of motor rotations per minute. Instead of using the automatic flow mode, the Impella was switched to manual P-control mode during this procedure. Level P8 was chosen as the start level, which corresponds to a high flow of ± 3.5 L/min. Flow of 1.5 L/min was chosen as the lower limit to prevent aortic regurgitation. In manual P-control mode, the P-levels have to be downregulated manually when suction alarms appear. During this procedure, no suction alarms occurred. No dislocation or interference due to the magnetic field was noted. However, the motor power and flow rate displayed on the AIC monitor seemed to be falsely elevated when the magnets were in navigation mode (average false elevation of flow of 0.5 L/min). Because MAP remained constant, a technical origin was suspected. Motor power and flow rate returned to baseline values when the magnets were moved to the stowed position.

Discussion

To the best of our knowledge, this is the first reported case in which hemodynamic support by the Impella continuous-flow MCS was used during RMN-guided VT ablation. Despite the magnetic field, the Impella functioned normally during the procedure.

There are different approaches for VT ablation. An ablation approach based on substrate modification does not require routine use of MCS. However, in patients with structural heart disease undergoing VT ablation, the numerous comorbidities, the complexity of underlying substrates, and procedural factors such as fluid overload and use of anesthesia might lead to acute hemodynamic decompensation.^{13,14} Moreover, only an average of 30% of

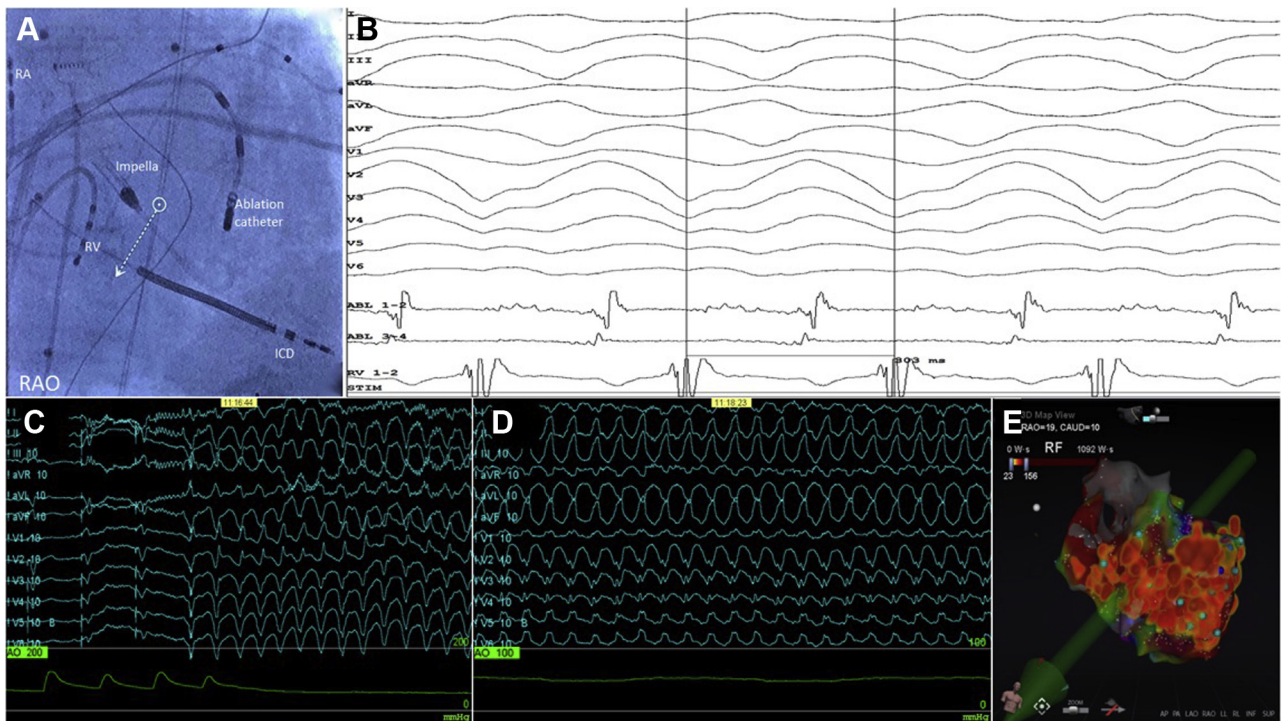


Figure 1 Several procedural recordings from the remote magnetic navigation-guided ventricular tachycardia (VT) ablation procedure. **A:** Fluoroscopic image of the Impella (Abiomed Inc, Danvers, MA) and catheters in the right anterior oblique (RAO) view. **B:** Intracardiac electrogram of a VT with a cycle length of 300 ms recorded during ablation. **C:** Surface electrocardiogram (ECG) and mean arterial pressure (MAP) curve showing induction of VT. The pulsatile MAP curve changes into a flat curve around 60 mm Hg because of the hemodynamic support provided by the Impella. **D:** Surface ECG and MAP recorded a few minutes later. MAP remains constant around 60 mm Hg during sustained VT. **E:** Image of the CARTO map (Biosense Webster, Diamond Bar, CA). All ablation points on the anterior wall of the left ventricle are visualized. ICD = implantable cardioverter-defibrillator; RA = right atrium; RF = radiofrequency; RV = right ventricle.

patients can hemodynamically tolerate VT.⁷ In the context of manually guided VT ablation, many studies reported on the safe use of continuous-flow MCS for periprocedural

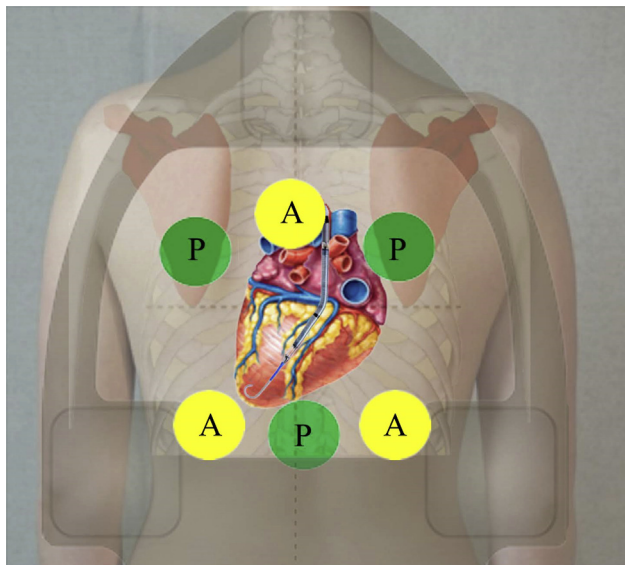


Figure 2 Schematic posteroanterior overview of positioning of the Impella CP continuous-flow mechanical circulatory support device (Abiomed Inc, Danvers, MA) and the CARTO patches (Biosense Webster, Diamond Bar, CA). The CARTO patches were positioned anterior and posterior on the chest and back of the patient so that the Impella CP motor was lying as far out of their field as possible. A = anterior; P = posterior.

hemodynamic support.^{8–10,13} Furthermore, emergent rescue MCS insertion during VT ablation because of hemodynamic collapse is associated with a high 30-day mortality compared to pre-emptive MCS insertion.¹⁵ Therefore, it is important to identify high-risk patients undergoing CA of scar-related VT for prophylactic MCS.¹⁴

Many studies compared RMN-guided with manual VT ablation^{3–5} and reported superiority of RMN with respect to acute success, recurrence, procedure time, fluoroscopy time, and complications. Compatibility of hemodynamic support devices with the preferential VT ablation technique is desirable. This case illustrates that it is possible to safely combine the Impella CP continuous-flow MCS with RMN-guided VT ablation. However, several hazards must be overcome when combining MCS with the strong magnetic fields used in RMN-guided ablation. The primary concern is the risk of EMI.¹¹ Theoretically, interference will be particularly seen when ablating in the LV outflow tract, right ventricular outflow tract, and septal wall because of proximity to the MCS motor. Based on early clinical experiences,¹² we advise careful positioning of the CARTO patches, AIC monitor, and catheters to reduce EMI as much as possible. In case of EMI, a possible resolution is lowering the P-level of the Impella until EMI resolves, as proposed by Vaidya and colleagues¹¹ (eg, from P8 to P6). Fortunately, this was not necessary in our case. When the magnets are in the navigation position before the MCS is activated, there is a theoretical hazard of motor

stop because of its alignment with the magnetic field. Therefore, it is recommended to position and start the MCS before activating the magnets. In automatic Impella motor control mode, measurements of the rotational speed of the motor could become inaccurate because of the magnetic field, and the flow rates could become uncontrollable. We observed that in navigation mode, Impella motor power and flow rate displayed on the AIC were falsely elevated and should be interpreted with care. Consequently, it is recommended to monitor MAP and use the manual P-control mode instead of the automatic mode. Our experience is based on a single case, and further research is warranted to establish the safety of combining the Impella CP continuous-flow MCS with magnetic-guided ablation. However, the 2 techniques seem to be compatible, which extends treatment options for patients experiencing hemodynamic unstable VTs.

Conclusion

The Impella CP continuous-flow MCS can be used to provide hemodynamic support during RMN-guided VT ablation.

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