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CASE REPORT

ADVANCED

CLINICAL CASE

First Report of Electromagnetic Interference Between Percutaneous Ventricular Assist Device and Implantable Cardioverter-Defibrillator

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ABSTRACT

Electromagnetic interference (EMI) between implantable left ventricular assist devices and cardiac implantable electronic devices has been observed. We demonstrated the first case of EMI between a percutaneous ventricular assist device and an implantable cardioverter-defibrillator, validated by an extra vivo simulation test. EMI might depend on the distance between devices. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2023;21:101981) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 47-year-old man (weight 53 kg, height 1.75 m, body surface area 1.68 m^2) with a history of end-stage hypertrophic cardiomyopathy experienced an appropriate implantable cardioverter-defibrillator (ICD) shock due to sustained ventricular tachycardia (VT) and was emergently admitted to a hospital. His hemodynamics deteriorated even with inotropic therapy; therefore, the percutaneous ventricular assist device (pVAD) Impella CP model (Abiomed) was inserted from the right femoral artery. The patient was transferred to our institution for further treatment because of refractory congestive heart failure. Immediately before transport, the patient developed a VT storm and was intubated. On arrival at our institution, systolic blood pressure decreased to 70 mm Hg. Noradrenaline was initiated, and the patient was admitted to the intensive care unit. A 12-lead electrocardiogram showed right atrial pacing and right ventricular pacing (RVp) with a heart rate of 70 beats/min (**Figure 1A**). The pVAD support level was P4 and could not be augmented because further support resulted in left ventricular collapse. RVp failure occurred suddenly (**Figure 1B**). We

LEARNING OBJECTIVES

- To recognize that EMI could occur between pVAD and CIEDs.
- EMI might be affected by the distance from the impeller within pVAD to the CIEDs.
- To review the solutions for EMI between pVAD and CIEDs.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

CIEDs = cardiac implantable electronic devices

EMI = electromagnetic interference

ICD = implantable cardioverter-defibrillator

LVAD = left ventricular assist device

pVAD = percutaneous ventricular assist device

RVp = right ventricular pacing

VA-ECMO = venoarterial-extracorporeal membrane oxygenation

VT = ventricular tachycardia

immediately attempted ICD interrogation by a programmer but could not establish device interrogation.

PAST MEDICAL HISTORY

The patient was diagnosed with hypertrophic cardiomyopathy at the age of 15 years. At 39 years, transvenous ICD was implanted (Ilesto 7 DR-T, Biotronik) on the left anterior chest due to sustained VT. He was examined at the outpatient clinic. His congestive heart failure symptoms gradually progressed to NYHA functional class III, with left ventricular dilation and systolic dysfunction.

DIFFERENTIAL DIAGNOSIS

Electromagnetic interference (EMI) by the pVAD might have disturbed the device interrogation.

INVESTIGATIONS

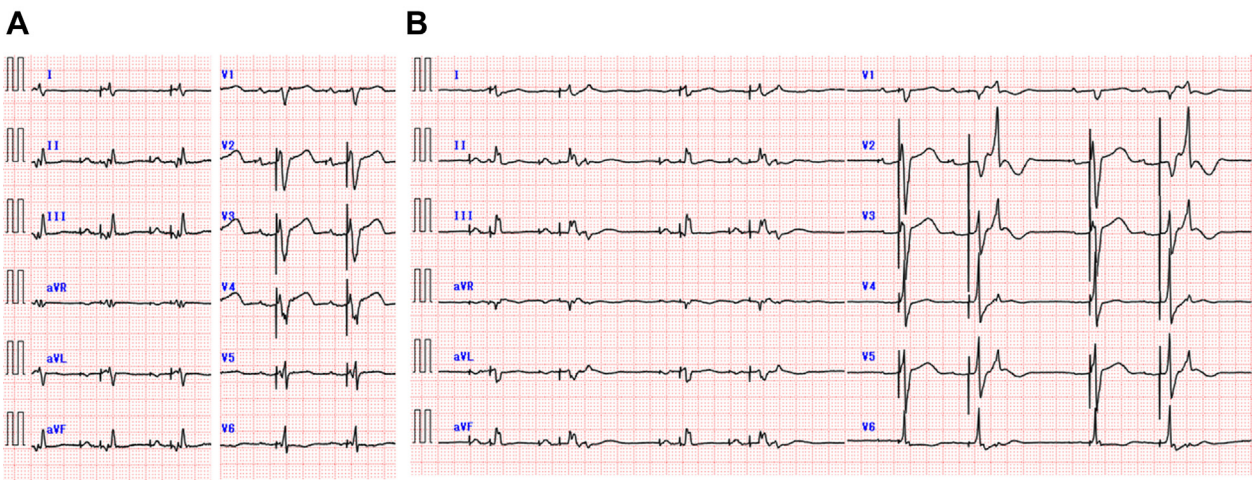
A temporary transvenous pacing catheter was inserted into the right ventricular apex. After a few hours, the RVp by the ICD recovered spontaneously; however, device interrogation remained impossible. Due to prolonged cardiogenic shock, venoarterial-extracorporeal membrane oxygenation (VA-ECMO) was initiated. Because we suspected the EMI by the pVAD disturbed the device interrogation, we attempted telemetry communication again while decreasing the pVAD flow under the VA-ECMO. We succeeded in interrogating the device only at P0. Once the device interrogation was established, telemetry programming remained possible, even after increasing the pVAD flow. Interrogation could not be conducted when there was more than P1 support. We validated the reproducibility of this phenomenon and concluded that the EMI generated by the pVAD disturbed device interrogation.

We confirmed whether the pVAD interfered with ICD interrogation using ex vivo simulation because EMI between pVAD and ICD has not yet been reported. We created an ex vivo system including the microaxial blood pump in a water tank and an ICD generator. Because the measured distance from the impeller within the pVAD to the ICD generator in vivo was 95.7 mm (**Figures 2A and 2B**), we placed them 95.7 mm apart in this system (**Figure 2C**). We turned the pVAD support down from P9 to P0 in steps, and the interrogation was established only at P0 (Video 1). When the distance between the devices was set at 120 mm, device interrogation was established even at the level of P9 (Video 1).

MANAGEMENT

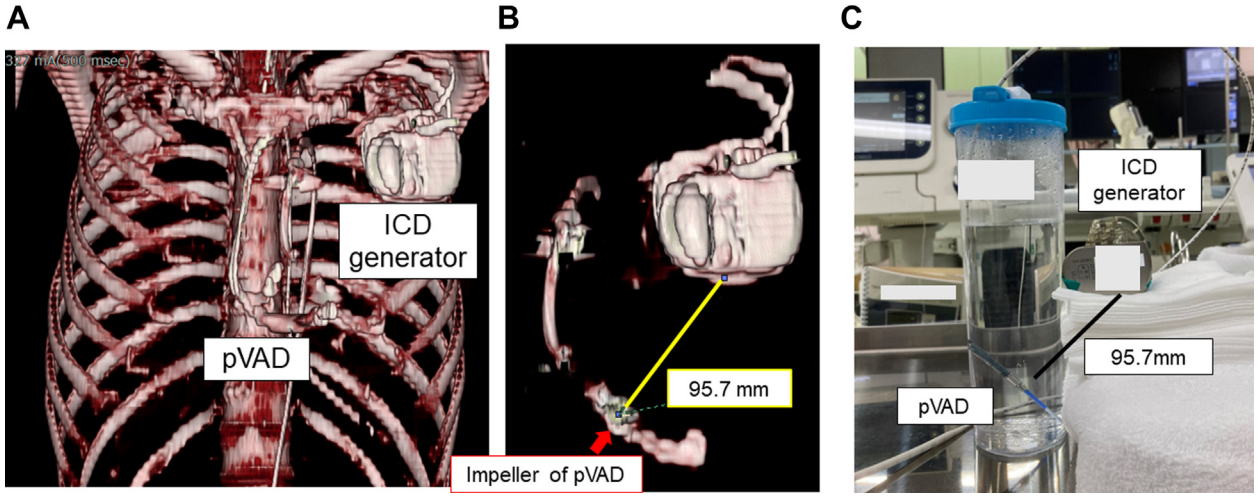
When necessary, we established a device interrogation while turning down the pVAD flow.

FIGURE 1 12-Lead ECG Findings



(A) Initial electrocardiogram (ECG) showing a heart rate of 70 beats/min with atrial pacing (Ap) and right ventricular pacing (RVp). **(B)** ECG showing captured Ap and failed RVp.

FIGURE 2 The Position and the Distance Between the pVAD and ICD



(A) Computed tomographic images showing the positional relationship between the percutaneous ventricular assist device (pVAD) and the implantable cardioverter-defibrillator (ICD). **(B)** The distance between the impeller within the pVAD and the ICD generator. **(C)** Ex vivo validation system of electromagnetic interference between the pVAD and ICD.

FOLLOW-UP

Despite receiving maximum intensive care, the patient died of multiple organ failure.

DISCUSSION

Here, we describe a case in which EMI generated by pVAD disturbed ICD interrogation. To the best of our knowledge, this is the first report of EMI between pVAD and cardiac implantable electronic devices (CIEDs). Previous reports described that EMI caused by an implantable left ventricular assist device (LVAD) resulted in pacing inhibition, inappropriate ICD shock, and failure to establish telemetry with the ICD.[1] Regarding pVAD, EMI with 3-dimensional mapping during catheter ablation has been published.[2,3] Moreover, the EMI between pVAD and ICDs has not been reported yet. The rotational motion of the impeller within the microaxial flow device generates EMI. In our case, the main problem was the inhibition of the device interrogation. We validated this phenomenon with an ex vivo test and concluded that this depended on the distance between the impeller within the pVAD and the ICD generator. Transient RVp failure may also have been affected by EMI; however, we could not confirm reproducibility because this occurred only once. Recently, pVADs have been used to treat cardiogenic shock. Given that patients with reduced left ventricular systolic function are often equipped with CIEDs, a similar situation may not be rare in recent clinical settings.

Previous reports have shown that the distance between the devices and the pump speed of the implantable LVAD are associated with the impact of EMI on the ICD.[1,4,5] Our case and experimental test suggested that this was applicable to EMI between the pVAD and ICD. Schnegg et al[5] reported that EMI by the LVAD was seen in the ICD at a very close distance (0-60 mm).

In our case, a Biotronik ICD was implanted. A previous study reported that patients with a HeartMate 3 LVAD experienced EMI mainly with Biotronik devices, whereas patients with HeartMate II experienced EMI with St Jude/Abbott ICDs.[6] Another report showed that EMI with HeartMate 3 was observed in Biotronik ICD, and not only in the Medtronic ICD[5]; hence, there might be differences in vulnerability to EMI among different manufacturers.

Some solutions for EMI between implantable LVADs and ICDs have been proposed. A previous study attempted to maximize the distance between the devices by pushing the ICD generator superiorly and extending the patient's arm on the head.[1] This method was used in this case. As the ICD implanted

8 years earlier was tightly adherent, we failed to move the device upward. Moreover, it is difficult to extend the arm compulsorily under sedation because the range of shoulder motion is limited.

In some cases, the "pan method,"[7] covering the LVAD pump on the body surface with an iron pan, was useful. We attempted this but failed. In this case, the most reliable solution was to lower the level of microaxial pump flow for interrogation temporarily because the hemodynamics were supported by VA-ECMO. However, in the case of EMI without VA-ECMO, we cannot help but turn down the pVAD flow during the shortest duration, which might increase the risk of collapse. In the case of implantable LVADs, reimplantation of an ICD can be considered stable.[8] However, reimplantation may be difficult because the pVAD is usually equipped in the acute and hemodynamically unstable phases. Because a definitive solution for EMI by pVAD has not been established, the various methods described here are worth attempting. While using pVAD, we should recognize the possibility of interaction with CIEDs.

CONCLUSIONS

Here, we describe a case where EMI generated by pVAD disturbed ICD interrogation. To our knowledge, this is the first report of EMI between a pVAD and ICD. EMI may be affected by the distance from the impeller within the pVAD to the CIEDs.

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REFERENCES

1. Mozes A, DeNofrio D, Pham DT, Homoud MK. Inappropriate implantable cardioverter-defibrillator therapy due to electromagnetic interference in patient with a HeartWare HVAD left ventricular assist device. *Heart Rhythm*. 2011;8:778-780.

2. Vaidya VR, Desimone CV, Madhavan M, et al. Compatibility of electroanatomical mapping systems with a concurrent percutaneous axial flow ventricular assist device. *J Cardiovasc Electrophysiol*. 2014;25:781-786.

3. Sullivan JS, Maitoza LA, Brysiewicz NR, Hall EK, Beach CM. Electromagnetic interference complicating Impella® use during pediatric ablation. *Ann Pediatr Cardiol*. 2022;15:533-535.

4. Jin C, Hsu J, Frenkel D, Jacobson JT, Iwai S, Ferrick A. Unique technique to relieve left ventricular assist device electromagnetic interference with an implantable cardioverter defibrillator. *J Cardiovasc Electrophysiol*. 2021;32:551-553.

5. Schnegg B, Robson D, Fürholz M, et al. Importance of electromagnetic interactions between ICD and VAD devices-Mechanistic assessment. *Artif Organs*. 2022;46:1132-1141.

6. Yalcin YC, Kooij C, Theuns DAMJ, et al. Emerging electromagnetic interferences between implantable cardioverter-defibrillators and left ventricular assist devices. *Europace*. 2020;22:584-587.

7. Sehatbakhsh S, Kushnir A, Kabach M, Kolek M, Chait R, Ghumman W. A case of electromagnetic interference between HeartMate 3 LVAD and implantable cardioverter defibrillator. *Pacing Clin Electrophysiol*. 2018;41:218-220.

8. Matthews JC, Betley D, Morady F, Pelosi F Jr. Adverse interaction between a left ventricular assist device and an implantable cardioverter defibrillator. *J Cardiovasc Electrophysiol*. 2007;18:1107-1108.

KEY WORDS electromagnetic interference, ICD, Impella, telemetry

APPENDIX For a supplemental video, please see the online version of this paper.