

# A case report of an unusual cause of increased impedance after generator exchange

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## Background

Remote monitoring has emerged as a complement to in-person care for patient with cardiac implantable electronic devices (CIEDs). It provides the care team with information about device integrity, programming issues, or other medical data (i.e. arrhythmias) and since 2015 has been recognized as a part of standard management by the Heart and Rhythm Society for all patients with CIEDs. However, while it can provide invaluable information to providers, the volume of generated data can increase the risk of oversight. We present a novel case of apparent device malfunction that on closer scrutiny was obvious, but provides a lesson in the mechanisms by which data can be artifactual.

## Case summary

A 62-year-old male presented after his cardiac resynchronization therapy-defibrillator (CRT-D) alerted him that his device was at an elective replacement interval (ERI). He underwent an uncomplicated generator exchange; however, 2 weeks later, a remote alert showed that his device was at ERI and all impedances were above the upper limit. Device interrogation the following day demonstrated that the new device was functioning appropriately and his home monitor had in fact paired with his old generator. He obtained a new home monitor, and subsequent remote transmissions have demonstrated that his device is functioning appropriately.

## Discussion

This case demonstrates the importance of careful review of details from home-monitoring data. While concerning for device malfunction, there could be alternative causes when alerts are generated by remote monitoring. To our knowledge, this is the first report of this mechanism of alert via a home-monitoring device and should be considered when reviewing unusual remote download data.

## Keywords

Cardiac implantable electronic device • Case report • Lead impedance • Remote monitoring

## ESC Curriculum

5.9 Pacemakers • 5.11 Cardiac resynchronization therapy devices • 5.10 Implantable cardioverter defibrillators

## Learning points

- Inspect device data carefully when new abnormalities are seen on remote transmission.
- It is important to ensure pairing of new devices to remote transmitters.
- If patients retain old generators, they should be instructed to keep their old devices away from remote transmitters.

## Introduction

Remote transmission has become a commonplace strategy to monitor cardiac implantable electronic devices (CIEDs). Since 2015, there has been a Class Ia recommendation by the Heart Rhythm Society to

support the use of remote monitoring with these devices as it has been shown to lead to earlier detection of life-threatening arrhythmias, device malfunction, or lead malfunction. Routine and event-driven remote monitoring can result in both clinically appropriate and inappropriate alerts. The purpose of this work is to highlight a feature of

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remote monitoring that may potentially be overlooked when remote transmission errors arise.

## Timeline

Case timeline	
October 2013	cardiac resynchronization therapy-defibrillator (CRT-D) placed
24 March 2021	Device alerted that it was at elective replacement interval
10 May 2021	Elective generator change
24 May 2021	Remote alert showing elective replacement interval and all impedances above the upper limit
25 May 2021	In-person device interrogation showed that device was functioning appropriately

## Case presentation

A 62-year-old male with a relevant past medical history for an ischaemic cardiomyopathy had a St. Jude Quadra Assura CRT-D device placed in 2013 for continued left ventricular systolic dysfunction and dyssynchronous ventricular activation. After device implantation, he had significant improvement in his left ventricular systolic function. His ejection fraction improved from 25% to 45% with resolution of his symptoms to New York Heart Association Class I. The patient's device went into elective replacement indicator mode in March of 2021, and an in-person interrogation revealed that his device was otherwise functioning well with normal impedances and pacing thresholds. The generator was electively exchanged in May of 2021 during an uncomplicated procedure; however, a routine remote transmission 2 weeks later was concerning for device malfunction (Figures 1, 2, and 3).

It was initially unclear as to why this alert occurred so shortly after a generator change. Common complications that may cause an acute impedance rise after this procedure include a conductor fracture or connector problem (i.e. incomplete pin insertion into the header or header-lead pin mismatch)<sup>1</sup>. However, this was felt to be unlikely given that the patient underwent an uncomplicated generator change and he was otherwise asymptomatic. Other causes, such as lead dislodgement or lead perforation, were also felt to be improbable as this was solely a generator change and the leads were not significantly manipulated.

Further scrutiny of the remote download data, along with dialog from the patient, confirmed the underlying cause of these remote alerts. The patient had chosen to keep his old pulse generator after the replacement, and his remote monitor had not yet been replaced. His home monitor had unintentionally paired with this old device, and these remote download findings were imitating a complication within the newly implanted device. In-person visit the following day reflected a normal exam, and vitals and in-clinic device interrogation demonstrated that the device was in good functioning order. The patient subsequently obtained a new monitor that paired with his new device, and further remote transmissions over the next 18 months showed that the device was functioning well (Figure 4).

## Discussion

Remote transmissions are useful in detecting early problems with pacemakers, defibrillators, and their corresponding leads. As observed in this scenario, a detected increase in lead impedance is initially concerning for a complication with lead integrity,<sup>1</sup> however troubleshooting such cases can often be difficult. For reasons that are not well understood, patients can intermittently develop high pacing impedance values that are not associated with any other lead abnormalities.<sup>2</sup> In fact, abrupt increases in lead impedance may actually not be due to a problem with device integrity and have actually correlated with a patient's demise.<sup>3,4</sup>

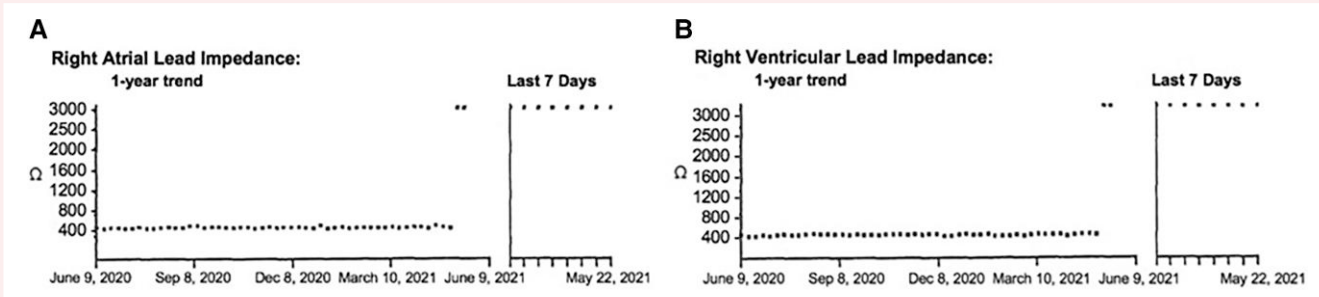
Patients being followed using remote monitoring typically have a high level of satisfaction with this technology and believe that it has a positive effect on their health.<sup>5</sup> However, an important limitation with remote monitoring is the staggering amount of data that can be generated by these systems. A large study previously demonstrated that 7.7 transmissions were generated per patient over a 12-month period and 40.2% of these were alerts.<sup>6</sup> There was a surprising lack of uniformity in the programming for these alerts, with various arrhythmias and device events being represented as both high and low acuity alerts depending on the preferences of individual physicians.<sup>6</sup> Many alerts can be false positives, with one study demonstrating a 46–86% false positive rate for remote transmission alerts from implantable loop recorders, depending on the indication for implantation.<sup>7</sup> As such, it is important for health care workers to inspect device data carefully when encountering new alerts as there may be alternative causes of apparent device malfunction when alerts are generated by remote monitoring.

## Conclusion

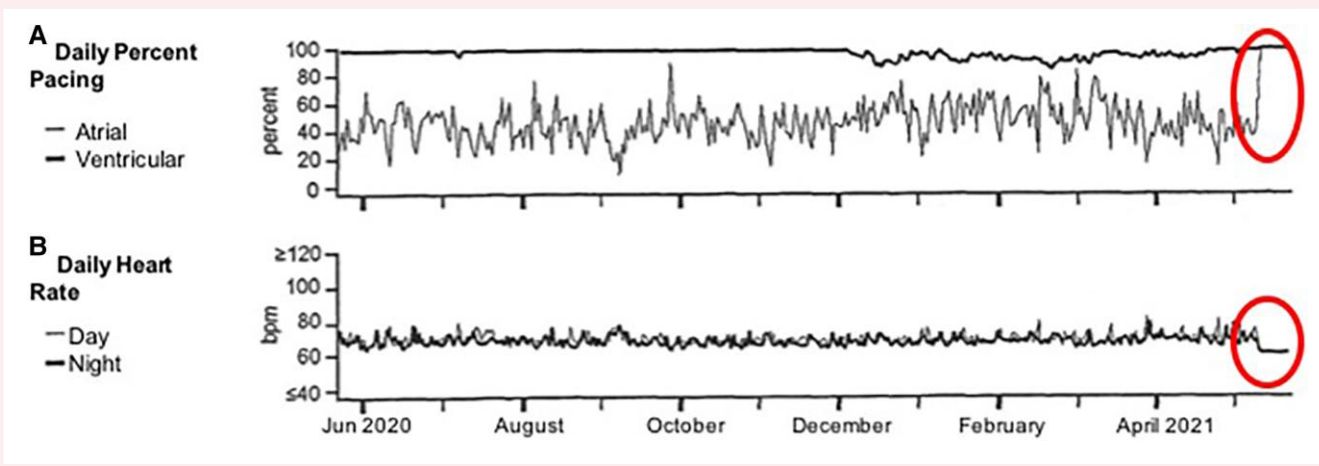
Remote cardiac monitoring has become commonplace in monitoring the integrity of both pacemakers and defibrillators. Although abnormal reported parameters can be related to device malfunction and lead fracture, uncommon causes are possible as well. Alerts from remote transmissions are common, and when new abnormalities are seen on

	Capture	Sense	Lead Impedance
A	Not Performed	Not Performed	>3000 Ω (Bi) ⓐ
RV	Unknown ⓐ	Not Performed	>3000 Ω (Bi) ⓐ
LV	Unknown ⓐ		>3000 Ω (M3-RVc) ⓐ
HV			>200 Ω (RV to Can) ⓐ

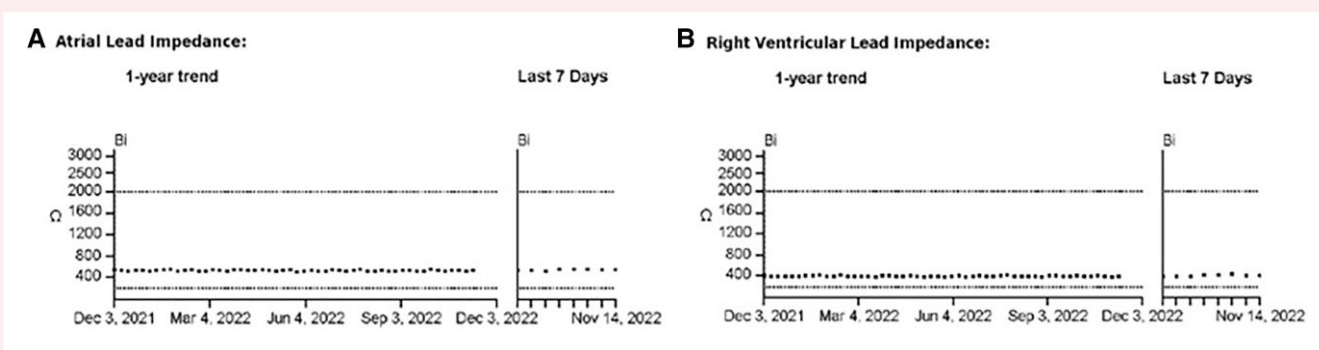
**Figure 1** Remote transmission summary two weeks after generator change. Device was unable to capture and lead impedance was out of range for all three leads (normal impedance range for these leads was 200–2000 Ω).



**Figure 2** Lead impedance trend during remote transmission on May 2022, 2 weeks after the generator change. The prior device remained connected to his original remote monitoring platform and was demonstrating high impedance values. Normal impedance range for this device was 200–2000 Ω. A and B represent the right atrial and right ventricular lead impedances, respectively.



**Figure 3** Trend of device activity for the old generator. A represents the amount of pacing in both the atria and ventricles, while B represents the daily average heart rate. Red circles represent the time frame after the generator change when the device was connected to the original remote monitoring platform. The device attempted to continuously pace at a rate of 60 bpm.



**Figure 4** Lead impedance trend during most recent remote monitoring in November 2022. The new device is now connected to a new remote monitoring platform and is functioning appropriately. Normal impedance range for this device was 200–2000 Ω. A and B represent the right atrial and right ventricular lead impedances, respectively.

remote transmission, it is of utmost importance to carefully scrutinize remote download data, to avoid unnecessary additional interventions.

## Lead author biography



Dr Daniel Feldman is currently a cardiovascular fellow at Dartmouth Hitchcock Medical Center. He completed his medical education at Drexel University College of Medicine and completed his internal medicine residency at Tufts Medical Center.

## Supplementary material

[Supplementary material](#) is available at *European Heart Journal – Case Reports*.

**Slide sets:** A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

**Consent:** Patient has provided written consent for this manuscript in accordance with COPE guidelines.

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## Data availability

The data underlying this article are available in the article and in its online [supplementary material](#).

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