

Pacemaker Malfunction Due to Electric Blanket: A Rare Case of Electromagnetic Interference

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INTRODUCTION

History of cardiac pacing began in the 1950s with the development of pacemakers tethered to an extension cord.¹ It was followed by the first fully implantable pacemaker in Arne Larson in 1958 by Ake Senning and Rune Elmqvist. The original system lasted only for eight hours, and Arne Larsson had to undergo over 20 pacemaker replacements, but he outlived both his surgeon and device engineer.

Since then, a remarkable collaboration among surgeons, physicians, engineers, businessmen, and patients has led to an extensive development in this field, including the development of leadless pacemakers. Today, there are three basic kinds of pacemakers: single chamber, dual chamber, or biventricular pacemakers.² The common indications for permanent pacemaker include sick sinus syndrome, symptomatic second- or third-degree atrioventricular blocks, bifascicular block, alternating bundle branch block, and recurrent syncope with ventricular asystole > 3 seconds. The modes of pacemaker are based on generic codes known as NBB code and typically consists of 4- or 5-letter code, in which the first position identifies the chamber paced (A for atrium, V for ventricle, D for dual), the second position: chamber sensed, the third position: device response to sensed events (I for inhibit, T for trigger, or D for dual), the fourth position: whether rate response is on, and the fifth position (when used), indicates whether multisite pacing is employed in the atrium (A), ventricle (V), or both (D).³

Being an electric device, pacemakers come with challenges that include battery failure, change in programming due to the patient's condition, circuit failures sourcing from lead damage, and electromagnetic interference (EMI).^{4,5} EMI can be caused by the electromagnetic waves generated by electromagnetic devices or procedures such as magnetic resonance imaging, cell phones, defibrillation, radiofrequency ablation, and radiation therapy. The incidence of EMI is variable but can occur in around 50% of patients with pacemakers.⁶ The EMI can lead to ventricular oversensing and inhibition of the pacing. Rarely, EMI can lead to mode switch.⁷⁻⁹ The current pacemakers with their noise-filtration techniques are fairly resistant to the common EMI sources like cellphones.⁷ The electromagnetic waves hamper the functionality and programming of the pacemaker, which puts the functionality of the device, as well as the patient, at risk.

In this report, a case of a rare pacemaker malfunction related to electromagnetic interference (EMI) from an electric blanket is presented. The case also emphasized the importance of good history taking and putting it in a relative clinical context to make a correct diagnosis.

CASE REPORT

An 85-year-old woman with past medical history of hypertension, dyslipidemia, coronary artery disease status post percutaneous intervention, sick sinus syndrome status, post dual-chamber pacemaker (St. Jude Medical®, device model Zephyr DR 5820), and paroxysmal atrial fibrillation on antiarrhythmic therapy with sotalol (demonstrating sinus rhythm) presented with complaint of the intermittent sense of pacemaker vibration at the generator site and occasional neck pulsations for the prior two weeks. She reported mild dyspnea and tiredness of relatively new onset.

Jugular venous pressure was normal with no evidence of leg edema. Physical examination was unremarkable. The patient denied any new activity or change in any dietary or medication regimen. Chest x-ray demonstrated normal lung parenchyma and normal pacemaker leads position. Pacemaker interrogation demonstrated that device was in VVI mode (while being in normal sinus rhythm) at the minimum backup rate which had stayed the same without variation for the prior two weeks, although it was last set at DDDR mode (the DDDR mode stands for D-dual chamber pacing, D-dual chamber sensing, D-response to sensed event which in this device case does both inhibit and trigger, and R-rate modulation which will increase paced heart rate in response to sensed “exercise”).

The patient's symptoms correlated with the device mode change. On objective inquiry to rule out possible causes, the patient denied unusual exposure to an electromagnetic interference including having undergone any exposure to magnets or unusual electrical devices. The device was reprogrammed to normal settings DDDR mode, and she felt better but returned two days later with similar symptoms. The device again was found to be reset in VVI mode.

The recurring auto resetting to VVI mode led to the suspicion of an external EMI interference. A comprehensive objective interrogation was conducted again and subsequently led to the final diagnosis and correct management. The patient recalled having been using an electric warming blanket (Sunbeam® brand) during sleep. In retrospect, the patient realized that she woke up with her symptoms after its first use, but initially could not comprehend the correlation between the electric blanket and the subsequent symptoms. Thus, she failed to disclose this information on her first presentation.

The pacemaker was reprogrammed to DDDR mode which resulted in resolution of symptoms. After discontinuing the use of the electric warming blanket, the recurrence of symptoms was not observed.

DISCUSSION

In general, EMI can originate from a variety of sources that have the potential to affect a pacemaker's function adversely, like device failure, device overheating, and hinderance in sensing ability.¹⁰ Some of the common sources of EMI with potential pacemaker effects are listed in Table 1.

Table 1. Possible pacemaker response based on electromagnetic interference exposure.

Type of Interference	Damage to Pacemaker	Total Inhibition	Rate Response
Cellular Phones	No	Yes	Yes
Magnetic Resonance Imaging	Yes	No	Yes
Electrocautery	U	Yes	Yes
Defibrillation	U	No	No
Extracorporeal Shock-Wave Lithotripsy	U	Yes	U
Therapeutic Radiation	Yes	No	No
Radiofrequency Ablation	U	Yes	U
Electroshock Therapy	U	U	U

U = Unlikely but may be possible.

Unipolar pacemakers are usually more susceptible to EMI interference than bipolar pacemakers because the sensing circuit encompasses a larger area compared with bipolar sensing.¹¹ Factors that affect EMI interference have to do with the source of interference, proximity to the pacemaker generator, and type of pacemaker. Usually, MRIs are contraindicated in patients with pacemakers, however, patients with newer MRI conditional pacemakers can undergo MRI scans safely without any adverse effects.¹²

Sources of EMI at home and the office usually do not pose a problem with patients, however, there is a potential concern that electronic surveillance devices found commonly in retail stores can interfere with pacemaker function, especially if patients are exposed to these devices for a prolonged period of time.^{13,14} The EMI can lead to a variety of responses to pacemakers, such as:

1. Inhibition of pacing output: this can be life threatening for the patients who are pacemaker dependent.
2. If the EMI is interpreted as atrial events by the pacemaker, then inappropriate ventricular pacing may occur in patients with DDD pacemakers, since these pacemakers attempt to track these events, which are interpreted as atrial activity.
3. EMI often results in electrical noise that causes the pacemaker to function in a noise reversion mode. The actual function of this mode differs among the different pacemakers, but this mode usually involves switching to an asynchronous pacing mode and acts as a protective algorithm from spurious signals. After elimination of the interference, pacers generally revert back to previously programmed mode.
4. Electric (power-on) reset: strong EMI can lead to high voltage

within device circuit which can cause reset of DDDR mode to VVI or VOO mode (Figure 1). Other causes of reset include electrocautery or external defibrillation. The reset mode does not revert to normal upon removal of EMI source (electric blanket in our case) and resolution requires programming by device.

5. Rare strong EMI can cause permanent damage to the pacemaker.



Figure 1. Schematic illustration of EMI-induced conversion to VVI pacing from DDDR pacing mode after electromagnetic interference.

In studies which examined interactions between pacemakers and cellular phones, it was noted that cell phones may cause intermittent pacemaker dysfunction.^{15,16} Various electronic devices can cause similar problems in pacemaker patients, but it is difficult to draw a firm line because of diversity of different electronic devices and pacemakers (especially newer models) that have different shielding capabilities and thresholds against EMI.

CONCLUSIONS

Although minor, the risk of interference between electromagnetic field and implanted medical devices is real. Pacemakers and implantable cardioverter defibrillators are subject to EMI, from many sources both within and outside the hospital environment, which are being implanted all around the world in modern medical era. The patients and the physicians who are responsible for follow-up of the pacing systems may be faced with challenges regarding the various types of EMI. To avoid these unwanted EMI effects, physicians and patients should be aware of these potential side effects of EMI on implantable electronic devices. Physicians must be vigilant and should demonstrate excellent history taking skills to formulate a correct diagnosis and management plan.

REFERENCES

- 1 Altman LK, Arne H, W. Larsson, 86; Had First Internal Pacemaker. New York Times, January 18, 2002, Section C, p. 15.
- 2 Dalia T, Amr BS. Pacemaker indications. August 22, 2022. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022. PMID: 29939600.
- 3 Mulpuru SK, Madhavan M, McLeod CJ, Cha YM, Friedman PA. Cardiac pacemakers: Function, troubleshooting, and management: Part 1 of a 2-part series. J Am Coll Cardiol 2017; 69(2):189-210. PMID: 28081829.
- 4 Butschek R, Farrell RM, Littmann L. ECG quiz: What is the cause of the apparent pacemaker malfunction? J Electrocardiol 2013; 46(2):108-109. PMID: 23620875.
- 5 Curtis GP, Lief LH. Arrhythmia resulting from sensing malfunction in a P wave triggered pacemaker. J Electrocardiol 1980; 13(4):401-404. PMID: 7430871.
- 6 Thaker JP, Patel MB, Jongnarangsin K, Liepa VV, Thakur RK. Electromagnetic interference with pacemakers caused by portable media players. Heart Rhythm 2008; 5(4):538-544. PMID: 18329961.
- 7 Jacob S, Panaich SS, Maheshwari R, Haddad JW, Padanilam BJ, John SK. Clinical applications of magnets on cardiac rhythm management devices. Europace 2011; 13(9):1222-1230. PMID: 21616944.

- ⁸ Stunder D, Seckler T, Joosten S, et al. In Vivo study of electromagnetic interference with pacemakers caused by everyday electric and magnetic fields. *Circulation* 2017; 135(9):907-909. PMID: 28242642.
- ⁹ Tiikkaja M, Aro AL, Alanko T, et al. Electromagnetic interference with cardiac pacemakers and implantable cardioverter-defibrillators from low-frequency electromagnetic fields in vivo. *Europace* 2013; 15(3):388-394. PMID: 23125355.
- ¹⁰ Hours M, Khati I, Hamelin J. Interference between active implanted medical devices and electromagnetic field emitting devices is rare but real: Results of an incidence study in a population of physicians in France. *Pacing Clin Electrophysiol* 2014; 37(3):290-296. PMID: 24033373.
- ¹¹ Thomas D, Becker R, Katus HA, Schoels W, Karle CA. Radiation therapy-induced electrical reset of an implantable cardioverter defibrillator device located outside the irradiation field. *J Electrocardiol* 2004; 37(1):73-74. PMID: 15132373.
- ¹² Cunqueiro A, Lipton ML, Dym RJ, Jain VR, Sterman J, Scheinfeld MH. Re: performing MRI on patients with MRI-conditional and non-conditional cardiac implantable electronic devices: an update for radiologists. A reply. *Clin Radiol* 2020; 75(5):390-391. PMID: 32172945.
- ¹³ Lakshmanadoss U, Chinnachamy P, Daubert JP. Electromagnetic Interference of Pacemakers. In: MK Das (Ed.). *Modern Pacemakers-Present and Future*. February 14, 2011. IntechOpen. <https://doi.org/10.5772/13137>.
- ¹⁴ Yazaki K, Watarai M, Kahata M, et al. Cause of the "power-on reset" phenomenon other than electric magnetic interference in a patient with a pacemaker. *Indian Pacing Electrophysiol J* 2018; 18(4):150-151. PMID: 29477310.
- ¹⁵ Francis J, Niehaus M. Interference between cellular telephones and implantable rhythm devices: A review on recent papers. *Indian Pacing Electrophysiol J* 2006; 6(4):226-233. PMID: 17031411.
- ¹⁶ Chhabra L, Hiendlmayr B, Kluger J. An adverse electrophysiological interaction between an implantable cardioverter-defibrillator and a ventricular assist device. *Conn Med* 2015; 79(6):351-354. PMID: 26263716.

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