


**BRIEF COMMUNICATION**

# Magnetic Interference on Cardiac Implantable Electronic Devices From Apple iPhone MagSafe Technology

Fahd Nadeem , MD; Arismendy Nunez Garcia, MD; Cao Thach Tran, MD, PhD; Michael Wu , MD

**BACKGROUND:** Magnet wireless charging is being utilized increasingly in current generation smartphones. Apple's MagSafe is a proprietary wireless charging technology with an array of magnets that has the capacity to generate magnet field strength >50 gauss (G). We hypothesize that there is clinically significant magnet interference caused by Apple's MagSafe technology on cardiac implantable electronic devices (CIED).

**METHODS AND RESULTS:** This study has an in vivo and an ex vivo component. The in vivo component consists of consecutive patients who presented to the electrophysiology laboratory with previously implanted CIEDs. The iPhone 12 Pro Max was directly placed on the skin over the pocket of these patients and the effect was studied by device interrogation. For the ex vivo component of the study, CIEDs from major device companies were tested for magnetic interference caused by iPhone 12 Pro Max through unopened packages. We found that iPhone 12 Pro Max resulted in clinically identifiable magnet interference in 3/3 (100%) participants in vivo and in 8/11 (72.7%) devices ex vivo.

**CONCLUSIONS:** Apple's iPhone 12 Pro Max MagSafe technology can cause magnet interference on CIEDs and has the potential to inhibit lifesaving therapy.

**Key Words:** hall-effect sensor ■ implantable cardioverter/defibrillator ■ magnet ■ pacemaker ■ reed switch ■ smartphone

**M**agnet reversion mode in cardiac implantable electronic devices (CIED) is triggered when an external magnet of adequate strength is applied over the device. In implantable cardioverter defibrillators (ICD) the magnet reversion response is inhibition of tachytherapies whereas in pacemakers the response is asynchronous pacing. Modern day cell phones are thought to have little to no risk of electromagnetic interference (EMI) on CIEDs.<sup>1,2</sup> Wireless charging is a new technology that utilizes a charging base that generates a magnetic field and induces voltage in the receiver coil of the mobile device, allowing it to charge wirelessly.<sup>3</sup> The current generation of Apple's iPhones utilize a wireless charging system termed MagSafe. This technology can provide wireless charging up to 15W and it is optimized with a ring-shaped magnet array.<sup>4</sup> We present a case series

of magnet interference on CIEDs caused by Apple's MagSafe technology.

## METHODS

The authors declare that all supporting data are available within the article.

The study population includes patients 18 years or older with Medtronic, Abbott, or Boston Scientific CIED's who presented to the electrophysiology laboratory for generator change or were seen by the inpatient electrophysiology consult team for interrogation. Informed consent was obtained prior to the study. A baseline device interrogation was performed to note settings and ensure appropriate functions. Subsequently, an iPhone 12 Pro Max was placed directly on the skin over the device of the patient and

Correspondence to: Michael Wu, MD, Brown University, 593 Eddy Street, APC 731, Providence, RI 02905. E-mail: michael.wu@lifefspan.org

For Sources of Funding and Disclosures, see page 4.

© 2021 The Authors. Published on behalf of the American Heart Association, Inc., by Wiley. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

JAHA is available at: [www.ahajournals.org/journal/jaha](http://www.ahajournals.org/journal/jaha)

**Table. Results of the In Vivo and Ex Vivo Portion of the Study**

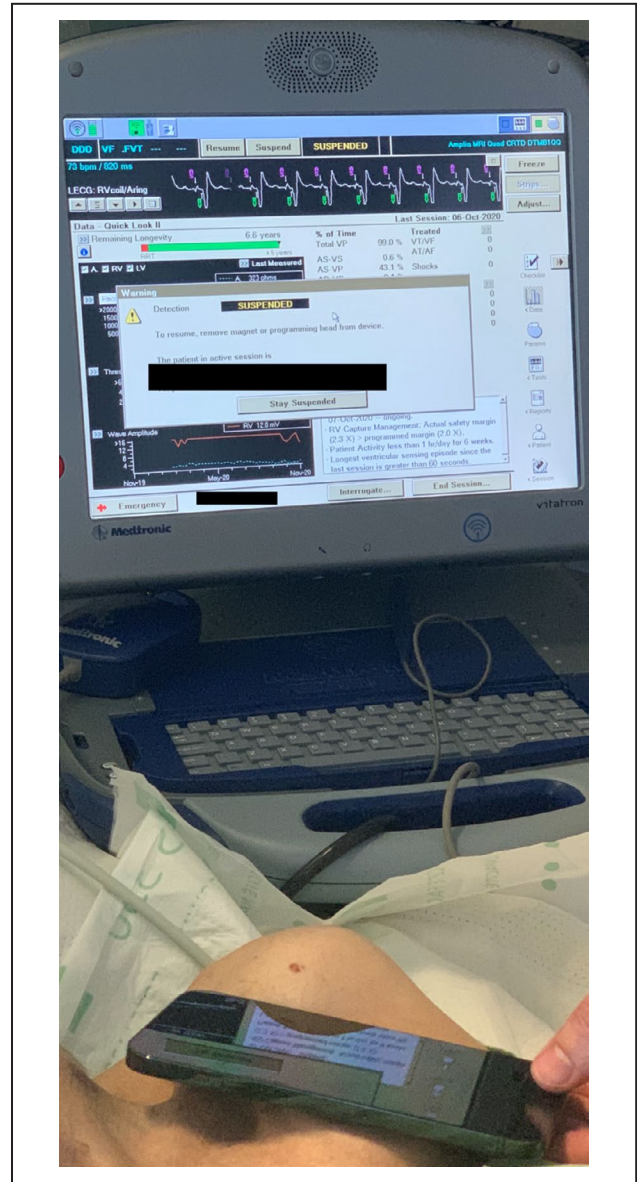
	Device Type	Response to iPhone 12 Pro Max
In vivo	Implantable cardioverter defibrillators	
	Medtronic Amplia MRI Quad CRTD	Inhibition of tachytherapies
	Abbott Medical 1231-40 Fortify VR	Inhibition of tachytherapies
	Pacemakers	
	Boston Scientific V273 Intua CRT-P	Temporary asynchronous pacing
Ex vivo	Implantable cardioverter defibrillators	
	Medtronic Visia AF MRI ICD	Inhibition of tachytherapies
	Abbott Fortify Assura DR ICD	Inhibition of tachytherapies
	Abbott Ellipse DR ICD	Inhibition of tachytherapies
	Boston Scientific Dynagen ICD	No observable effect on the device
	Boston Scientific Emblem MRI S-ICD	No observable effect on the device
	Pacemakers	
	Medtronic Azure	Asynchronous pacing
	Medtronic Advia MRI	Asynchronous pacing
	Medtronic Adapta	Asynchronous pacing
	Abbott Assurity MRI	Asynchronous pacing
	Boston Scientific Accolade MRI	No observable effect on the device
	Boston Scientific U125 Valitude	Temporary asynchronous pacing

a programmer and telemetry were used to check for activation of magnet mode. A standard donut magnet was used to ensure activation of magnet mode was possible. All interrogations and intracardiac electrograms were adjudicated by at least 2 members from the electrophysiology team.

For the ex vivo component of our study, a programmer with wireless connection was established with each brand new packaged CIED. A standard donut magnet was used to ensure magnet mode activation was possible for each packaged device. The iPhone 12 Pro Max was then placed directly over the packaged CIED. Additionally, the magnet strength of the iPhone 12 Pro Max was measured using a magnetometer.

**RESULTS**

Our in vivo study population consists of three consecutive patients who presented for a generator change or device interrogation. The devices represented were Medtronic Amplia MRI Quad CRT-D, Abbott Medical 1231-40 Fortify VR, and Boston Scientific V273 Intua



**Figure 1. iPhone 12 Pro Max placed on the skin over Medtronic Amplia MRI Quad CRT-D device triggering magnet reversion mode.**

CRT-P. Baseline device interrogations revealed normal functioning device and leads. 2/3 devices were at elective replacement indicator (ERI) and none were at end of life (EOL). A standard donut magnet was used to ensure magnet reversion can be triggered in all patients. The results of our study can be seen in Table. Magnet reversion mode was triggered by the iPhone 12 Pro Max in 3/3 (100%) of patients in vivo. An illustration of magnet reversion on a Medtronic device can be seen in Figure 1. The Boston Scientific V273 Intua CRT-P device appeared to be less susceptible as we were only able to elicit transient temporary asynchronous pacing but no sustained response by the iPhone 12 Pro Max magnet.

For the ex vivo portion of our study, the iPhone 12 Pro Max was placed over still-packaged new devices. A total of 11 devices, both pacemakers and ICDs from the major device companies, were tested. The results are listed in Table. Selected Medtronic and Abbott devices tested were susceptible to EMI. The Boston Scientific devices appeared to be less susceptible as no clear magnet interference was noted in the selected devices listed in Table. There was temporary asynchronous pacing but no sustained response on the U125 Valitude as demonstrated in Figure 2. Using the Medtronic Visia AF MRI ICD we found that the iPhone 12 Pro Max was able to trigger magnet reversion mode at a distance up to 1.5 cm from the anterior aspect of the device ex vivo. We tested the magnetic field strength of the iPhone 12 Pro Max using a magnetometer and found that it can be greater than 50 G. This is tested near the center of the ring-shaped magnet array at the back surface.

## DISCUSSION

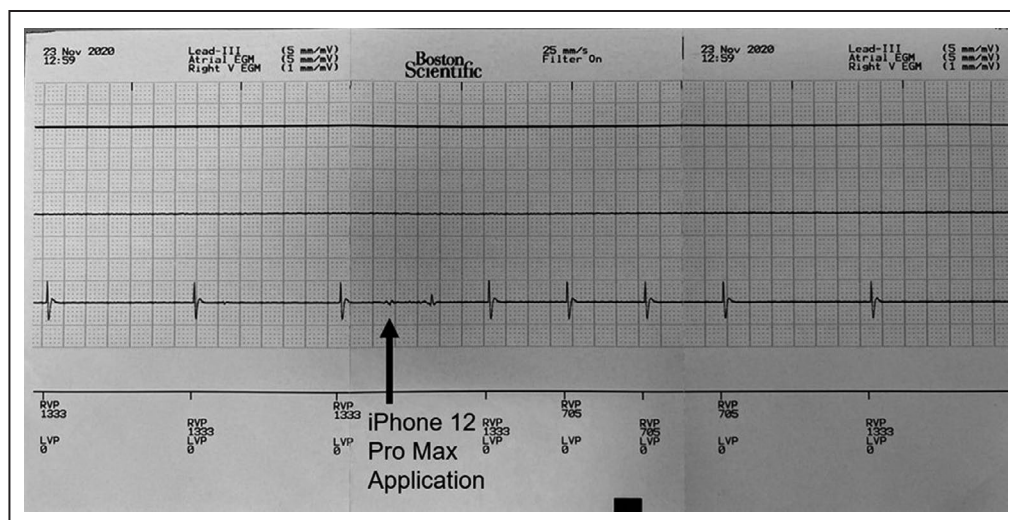
Our study demonstrates that magnet reversion mode may be triggered when the iPhone 12 Pro Max is placed directly on the skin over an implantable cardiac device and thus has the potential to inhibit life-saving therapies. Select devices from all three major device companies were found to have magnetic susceptibility.

Modern day CIEDs use hall-effect sensors, magnetosensitive resistors, or telemetry coils that are designed to respond to an external magnetic source.<sup>5</sup> The magnetic field created by wireless charging technology is monitored for interactions with CIEDs and

was found to be within the FDA standard ISO 14117.<sup>3</sup> Apple's MagSafe is a proprietary technology which utilizes wireless charging with an added neodymium magnet array for charging optimization. The newer generation iPhone 12 utilizes this technology, and it has more magnets than the previous generations. A recently published case report demonstrates the iPhone 12 causing a magnet response in a Medtronic device.<sup>6</sup> Apple Inc, has an advisory stating that the newer generation iPhone 12 does not pose a greater risk for magnet interference when compared to the older generation iPhones.<sup>7</sup> However, our study suggests otherwise as magnet response was demonstrated in 3/3 cases in vivo. In comparison to the older generation iPhone 6, a study performed by Lacour et al, found no cases of magnet response in a sample size of 148 patients.<sup>8</sup>

Magnet mode activation had been shown to occur in CIED's with exposure to a magnetic field as little as 10 G.<sup>9</sup> The magnetic field strength of the iPhone 12 Pro Max can be greater than 50 G when in direct contact with the magnetometer. In our ex vivo study, we were able to trigger magnet reversion by placing the iPhone 12 Pro Max at up to 1.5 cm from certain CIED. The difference in magnet response to the iPhone 12 Pro Max among different devices is likely attributed to different hall-sensor magnet sensitivity as all of the devices were susceptible to the standard donut magnet. Boston Scientific Accolade MRI pacemaker for example requires a magnet stronger than 70 G to activate magnet mode.<sup>10</sup>

Our case series has several clinical implications. People often put their smartphones in a breast pocket over a device which can be in close proximity to CIEDs. This can lead to asynchronous pacing or disabling



**Figure 2.** iPhone 12 Pro Max placed over Boston Scientific U125 Valitude ex vivo temporarily increasing the pacing rate to 85 beats per minute, which is the magnetic reversion rate for Boston Scientific devices.

of anti-tachycardic therapies. Our study adds to the growing literature demonstrating EMI from magnets in several common technological products such as smart tablets, E-cigarettes, fitness watch wristbands, and wireless headphones.<sup>11–14</sup>

Our case series has several limitations. Our sample size is small and we tested on selected device types and the results of our study may not be generalizable. A large scale study should be performed to confirm our findings.

In conclusion, this report highlights the importance of public awareness regarding an interaction between CIEDs and a recently released smartphone model with magnetic charging capability. Although the Food and Drug Administration website states that cellphones do not pose a significant health risk for patients with these devices, they do acknowledge that certain precautions may be advisable.<sup>15</sup> Based on the variability of interactions with respect to different smartphone models, patients are advised to consult with a heart rhythm specialist regarding recommendations specific to their smartphone and CIED.

## ARTICLE INFORMATION

Received January 12, 2021; accepted April 9, 2021.

### Affiliation

Division of Cardiology, Department of Medicine, Lifespan Cardiovascular Institute and Brown University, Providence, RI.

### Sources of Funding

None.

### Disclosures

None.

## REFERENCES

- Ismail MM, Badreldin AMA, Heldwein M, Hekmat K. Third-generation mobile phones (Umts) do not interfere with permanent implanted

- pacemakers. *Pacing Clin Electrophysiol*. 2010;33:860–864. DOI: 10.1111/j.1540-8159.2010.02707.x.
- Health C for D and R. Potential cell phone interference with pacemakers and other medical devices. FDA. Published online October 2, 2020.
- Seckler T, Jagielski K, Stunder D. Assessment of magnetic interference with active cardiovascular implantable electronic devices (CIEDs) caused by the Qi A13 design wireless charging board. *Int J Environ Res Public Health*. 2015;12:5886–5904. 10.3390/ijerph120605886.
- Accessory design guidelines for Apple devices. Apple Inc website. Updated October 16, 2021. Available at: <https://developer.apple.com/accessories/Accessory-Design-Guidelines.pdf>. Accessed December 10, 2020.
- Jacob S, Panaich SS, Maheshwari R, Haddad JW, Padanilam BJ, John SK. Clinical applications of magnets on cardiac rhythm management devices. *Europace*. 2011;13:1222–1230. DOI: 10.1093/europace/eur137.
- Greenberg JC, Altawil MR, Singh G. Letter to the editor-lifesaving therapy inhibition by phones containing magnets. *Heart Rhythm*. 2021;S1547-5271(20)31227-3. DOI: 10.1016/j.hrthm.2020.12.032.
- Apple Support. *About the magnets inside iPhone 12, iPhone 12 mini, iPhone 12 Pro, iPhone 12 Pro Max, and MagSafe accessories*. [online]. 2021. Available at: <https://support.apple.com/en-us/HT211900>. Accessed February 19, 2021.
- Lacour P, Parwani AS, Schuessler F, Hohendanner F, Heinzel F, Trippel T, Boldt L, Pieske B, Blaschke F. Are contemporary smartwatches and mobile phones safe for patients with cardiovascular implantable electronic devices? *JACC Clin Electrophysiol*. 2020;6:1158–1166. DOI: 10.1016/j.jacep.2020.04.033.
- Bhachu DS, Kanal E. Implantable pulse generators (pacemakers) and electrodes: safety in the magnetic resonance imaging scanner environment. *J Magn Reson Imaging*. 2000;12:201–204. DOI: 10.1002/1522-2586(200007)12:1<201:AID-JMRI23>3.0.CO;2-G.
- Boston Scientific Reference Guide. Available at: [https://www.bostonscientific.com/content/dam/Manuals/us/current-rev-en/359239-002\\_multi\\_RG\\_en-US\\_S.pdf](https://www.bostonscientific.com/content/dam/Manuals/us/current-rev-en/359239-002_multi_RG_en-US_S.pdf) (page 117). Accessed April 25, 2021.
- Shea JB, Aguilar M, Sauer WH, Tedrow U. Unintentional magnet reversion of an implanted cardiac defibrillator by an electronic cigarette. *HeartRhythm Case Rep*. 2020;6:121–123. DOI: 10.1016/j.hrcr.2020.01.013.
- Lee S, Fu K, Kohno T, Ransford B, Maisel WH. Clinically significant magnetic interference of implanted cardiac devices by portable headphones. *Heart Rhythm*. 2009;6:1432–1436. DOI: 10.1016/j.hrthm.2009.07.003.
- Kozik TM, Chien G, Connolly TF, Grewal GS, Liang D, Chien W. iPad2(R) use in patients with implantable cardioverter defibrillators causes magnetic interference: the EMIT study. *J Am Heart Assoc*. 2014;3:e000746. DOI: 10.1161/JAHA.113.000746.
- Asher EB, Panda N, Tran CT, Wu M. Smart wearable device accessories may interfere with implantable cardiac devices. *HeartRhythm Case Rep*. 2020;7:167–169. DOI: 10.1016/j.hrcr.2020.12.002.
- Center for Devices, Radiological Health. Potential cell phone interference with pacemakers and medical devices. fda.gov. Published October 2, 2020. Available at: <https://www.fda.gov/radiation-emitting-products/cell-phones/potential-cell-phone-interference-pacemakers-and-other-medical-devices>. Accessed March 17, 2021.