Is it safe for patients with cardiac implantable electronic devices to charge electric vehicles?

A look at the potential consequences.

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ABSTRACT: Patients with cardiac implantable electronic devices (CIEDs) are susceptible to electromagnetic interference and its potential harmful consequences from a variety of sources. Recent widespread consumer adoption of electric vehicles poses a new source of electromagnetic interference in the daily environment for patients with CIEDs. Current research shows no interference for CIED patients charging electric vehicles at low power; however, the effects of high-powered electric vehicle charging have yet to be experientially tested. Understanding the potential consequences of this powerful technology for patients with CIEDs is necessary to keep them safe while progressing toward a more sustainable future.

Introduction

Cardiac implantable electronic devices (CIEDs), including pacemakers, implantable cardiac defibrillators, and cardiac resynchronization, have become well established standards of care for a variety of tachyarrhythmias, bradyarrhythmias, and in more recent years, heart failure.[1-3] Cardiac implantations have been increasing globally due to improvements in technology, growing medical indications, and an aging population.[4,5]

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More than 1 million cardiac implants in 61 countries occurred during 2009, a substantial increase over the previous world pacing survey conducted in 2005.[4] CIEDs are known to be susceptible to electromagnetic interface (EMI) from environmental, industrial, and hospital sources.[6-9] The electric current flowing through these sources generates a magnetic field (valid proxy for EMI) that can induce electrical fields in CIED circuitry, leading to pacing inhibition, device reprogramming, and inappropriate shock delivery.[9] Electric vehicles (EVs) have become ubiquitous in the global vehicle market and pose a new potential environmental source of EMI for CIED patients, especially as it pertains to their high-powered charging.[10]

Effects of electromagnetic interference on cardiac devices

During EV charging, the current flow in the charging cable creates a magnetic field that can potentially induce EMI in nearby devices. It has been experimentally shown that current flowing through an electronic arc welder cable during operation generated a magnetic field strength of 100–130 micro Tesla (μT), and induced inappropriate atrial sensing in a participant with a unipolar sensing pacemaker.[11] Current CIEDs almost exclusively use bipolar leads and have a higher magnetic field threshold of about 300mT before EMI is apparent.[12,13] Ventricular oversensing is clinically the most relevant problem caused by EMI, which may lead to asystole in the case of pacing inhibition in pacemaker-dependent patients. Device manufacturers have taken many steps to limit EMI on modern CIEDs through shielding, filters, bipolar leads, and components with less ferromagnetic material.[9] Despite these efforts, there remain reports of EMI in the general environment at an incidence of 0.27% per patient per year.[14] As EV charging continues to become more powerful with higher current flow, it is important to test whether charging an EV can generate a magnetic field strong enough to cause EMI in patients with CIEDs.

Safety of electronic transportation systems

Current research assessing the safety of electrically powered transportation systems for patients with CIEDs shows no measurable interference. Magnetically levitated linear motor cars, trains, trams, and hybrid vehicles have proven to be safe for patients with CIEDs to ride in and or operate.[15-17] More recently, the magnetic fields generated during regular-powered charging of the consumer EVs Volkswagen e-up!, BMW i3, Nissan Leaf, Tesla model 85S, and Tesla model S P90D have been examined on patients with CIEDs.[18,19] The highest magnetic field recorded was 116.5 mT by the Tesla model 85S around the charging cable. In both experiments there were no episodes of over- or undersensing, inappropriate pacing, pacing inhibition, or device reprogramming. Furthermore, Lennerz and colleagues recently published the complete methodological details of their 2018 study, highlighting the wide selection of cardiac devices tested and thus the generalizability of their safety results.[20] Both experiments had a small sample size and were underpowered to detect rare events; nonetheless, CIED patients should feel reassured operating and charging EVs under similar circumstances.

High-powered electric vehicle charging

Currently, EV manufacturers such as Tesla have established a public global network of high-powered charging stations for their vehicles. The "supercharging" offered by Tesla is able to charge their EVs faster using higher current flow. It was shown experimentally that magnetic field strength around the charging cable during Tesla EV charging increased almost proportionally with current flow.[19] Tesla V2 direct current superchargers generate a current flow twelvefold higher than the charging that has been experimentally tested on participants with CIEDs. This creates the potential for generating magnetic fields around the charging cable that exceed the 300 mT shown to cause EMI in unipolar and bipolar CIEDs in vivo.[12,13] Caution is warranted given the gap in knowledge surrounding the effects of high-powered EV charging on CIED function.

Conclusion

Manufacturers of CIEDs are regularly improving their safety and effectiveness; however, these devices are not without risks and will likely continue being susceptible to EMI from a variety of sources. Currently, EV manufacturers offer the capability to charge at much higher powers than previously shown to be safe. More research is needed to elucidate the effects of high-powered EV charging on patients with CIEDs and allow for the continued adoption of more efficient and powerful EVs without sacrificing safety. ■

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Competing interests

None declared.

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