

Magnetic Resonance Imaging-Conditional External Cardiac Defibrillator

Expanding Access and Safety During Magnetic Resonance Imaging

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Magnetic resonance imaging (MRI) is the most rapidly growing imaging modality in clinical medicine, including cardiac disorders.¹ One of the limitations of MRI is the need to avoid certain metallic objects in close proximity to the MRI machine, including external cardiac defibrillators. Similarly, patients with implantable devices with ferromagnetic components are contraindicated for MRI because of the risks of heating, dislodgement, and other problems. Included in this contraindicated list are patients with implantable cardiac rhythm devices, although it is estimated that a large number of such patients will be indicated for an MRI.² This has led to medical device manufacturers modifying the designs of pacemaker systems to make them MRI-conditional. The modifications included using less ferromagnetic material, developing lead wires with reduced radiofrequency heating to prevent thermal damage at the point of contact with the myocardium, and reducing electromagnetic interference to prevent inappropriate pacing and changes to provide battery protection. There are now robust data supporting the safety and reliability of MRI with the implantable pacemakers.^{3,4} MRI-conditional implantable cardioverter defibrillator systems have recently become available as well with several studies, supporting safety and low risk when exposed to 1.5-T whole-body MRI. Implantable cardioverter defibrillator systems evaluated after MRI revealed no delay in detection or treatment of ventricular tachyarrhythmias.⁵⁻⁷ However, these devices are inactivated for arrhythmia therapy while in the MRI bore.

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Patients who have implantable cardioverter defibrillator systems have, by definition, an increased risk of ventricular arrhythmias. These patients, as well as other groups of cardiac patients and severely ill noncardiac patients, are at risk for cardiac arrhythmias and are not protected in the MRI procedure room. Arrhythmia diagnosis is equally challenging because electrocardiogram monitoring cannot be performed during MRI, so pulse oximetry is often used to assess heart

rate. Cardiac arrest during MRI requires inactivating the scan, removing the patient from the bore, recording a rhythm, and defibrillating if appropriate. This significantly prolongs time to detection and time to return of spontaneous circulation, which is directly related to neurological outcomes and survival.⁸ Prompt defibrillation is now the cornerstone of resuscitation from cardiac arrest. Although the incidence of cardiac arrests in the MRI scanner is not known to our knowledge, it is logical to make MRI available and safer for high-risk patients.

In this issue of *Circulation: Cardiovascular Imaging*, the study by Schmidt et al⁹ aimed to make a commercial external cardiac defibrillator 1.5-T MRI-conditional. They applied some of the same modifications used in MRI-conditional implantable cardioverter defibrillator systems. This included adding a low pass filter to remove the large amount of radiofrequency interference emitted by the generator. To prevent the MRI-induced heating of the cables, they constructed a long high-voltage cable using copper-insulated cable and placed radiofrequency traps constructed from copper tubes at increments along the cable. MRI-compatible 12-lead ECG systems are being developed; however, they were not available at the time of this study, so MRI-compatible hemodynamic and oxygenation monitors were used as a surrogate.

Similar to the studies of the MRI-conditional implantable cardiac devices, the goals of this study included determining the safety of the equipment, the efficacy of the therapy (ie, defibrillation), and the preservation of image quality. Studies were performed in both swine and healthy human volunteers. Further studies are needed to validate these results and combine this system with the MRI-compatible electrocardiogram leads. It will also be important to establish whether transcatheter pacing can be achieved with this system.

This interesting article established the potential of MRI-conditional external cardiac defibrillators. If this system proves to be safe, effective, and can be commercialized, then this will help to eliminate one of the important barriers to MRI in high-risk or critically ill patients. With the growing field of MRI-guided interventions, an MRI-conditional external cardiac defibrillator with monitoring and pacing capabilities will be an important step toward providing care comparable to that in cardiac procedural rooms.

Disclosures

None.

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