

SPECIALTY AREA: New and emerging techniques

SAMAN NAZARIAN

snazarian@jhmi.edu

HIGHLIGHTS

- The use of magnetic resonance (MR) imaging as a diagnostic technique is rapidly expanding and MRI has become the modality of choice for imaging of various soft tissue structures without radiation or the use of iodinated contrast media.¹
- The number of patients who undergo implantation of cardiovascular devices is increasing. It is estimated that up to 75% of pacemaker and ICD recipients will develop an indication for MRI.^{2,3}
- However, implantable cardiac devices are subject to multiple effects from MRI, including movement secondary to magnetic field induced force and torque, electrical current induction within the field resulting in myocardial capture, and heating and tissue damage.⁴⁻⁸
- This session will review a safety protocol for non-cardiac and cardiac MRI of patients with standard permanent pacemakers or ICDs.

MRI IN PATIENTS WITH DEVICES

- **TARGET AUDIENCE** – Cardiologists, cardiac electrophysiologists, and radiologists interested in providing imaging services to cardiac device recipients.
- **OUTCOMES/OBJECTIVES** – To review the safety protocol, including the ability to a) identify cardiac device systems and configurations that are low risk for MRI, and b) appropriate device programming and monitoring steps during MRI.
- **PURPOSE** – To enable the diagnostic and therapeutic uses of MRI for cardiac device recipients.
- **RESULTS** - We have published our results including long-term follow up of 555 MRI studies in 438 patients with implantable devices. The median age of our patient population was 68 years, and of all patients, 54% had pacemakers and 46% had ICDs. Of all patients, 22% had complete heart block. The majority of MR examinations performed in our cohort imaged the brain and spine (40% and 22%, respectively). Fifteen percent of our patient population underwent repeat MR imaging for clinical follow-up of diagnostic findings and/or treatment effects. When comparing immediate post MR examination to pre-examination values, we observed statistically significant but clinically small changes in several device variables. These

changes included minor decreases in right ventricular sensing and atrial and right and left ventricular lead impedances. Long-term changes were also observed, including decreased right ventricular sensing and impedance, increased right ventricular capture threshold, and decreased battery voltage. Neither immediate nor long-term changes in device parameters were large enough to require lead or system revision or device reprogramming. In 3 of 438 patients in our recently reported cohort, the implantable cardiac device exhibited acute power-on-reset events. Of note, during long-term follow-up interrogations, there was no evidence for device malfunction in patients who experienced power-on-reset events.⁹

- **DISCUSSION** – MRI can be safely performed in patients with certain pacemaker and ICD systems using a protocol based on device selection, programming, and close patient monitoring.
- **CONCLUSION** – The ability to perform MRI in the millions of patients with implanted cardiac devices can have significant diagnostic and therapeutic benefits.
- **REFERENCES:**
 1. Marcu CB, Beek AM, van Rossum AC. Clinical applications of cardiovascular magnetic resonance imaging. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne*. 2006;175:911-917
 2. Kalin R, Stanton MS. Current clinical issues for mri scanning of pacemaker and defibrillator patients. *Pacing and clinical electrophysiology : PACE*. 2005;28:326-328
 3. Levine GN, Gomes AS, Arai AE, Bluemke DA, Flamm SD, Kanal E, Manning WJ, Martin ET, Smith JM, Wilke N, Shellock FS. Safety of magnetic resonance imaging in patients with cardiovascular devices: An american heart association scientific statement from the committee on diagnostic and interventional cardiac catheterization, council on clinical cardiology, and the council on cardiovascular radiology and intervention: Endorsed by the american college of cardiology foundation, the north american society for cardiac imaging, and the society for cardiovascular magnetic resonance. *Circulation*. 2007;116:2878-2891
 4. Roguin A, Zviman MM, Meininger GR, Rodrigues ER, Dickfeld TM, Bluemke DA, Lardo A, Berger RD, Calkins H, Halperin HR. Modern pacemaker and implantable cardioverter/defibrillator systems can be magnetic resonance imaging safe: In

vitro and in vivo assessment of safety and function at 1.5 t. *Circulation*. 2004;110:475-482

5. Nazarian S, Halperin HR. How to perform magnetic resonance imaging on patients with implantable cardiac arrhythmia devices. *Heart rhythm : the official journal of the Heart Rhythm Society*. 2009;6:138-143
6. Tandri H, Zviman MM, Wedan SR, Lloyd T, Berger RD, Halperin H. Determinants of gradient field-induced current in a pacemaker lead system in a magnetic resonance imaging environment. *Heart rhythm : the official journal of the Heart Rhythm Society*. 2008;5:462-468
7. Sommer T, Naehle CP, Yang A, Zeijlemaker V, Hackenbroch M, Schmiedel A, Meyer C, Strach K, Skowasch D, Vahlhaus C, Litt H, Schild H. Strategy for safe performance of extrathoracic magnetic resonance imaging at 1.5 tesla in the presence of cardiac pacemakers in non-pacemaker-dependent patients: A prospective study with 115 examinations. *Circulation*. 2006;114:1285-1292
8. Vahlhaus C. Heating of pacemaker leads during magnetic resonance imaging. *European heart journal*. 2005;26:1243; author reply 1243-1244
9. Nazarian S, Hansford R, Roguin A, Goldsher D, Zviman MM, Lardo AC, Caffo BS, Frick KD, Kraut MA, Kamel IR, Calkins H, Berger RD, Bluemke DA, Halperin HR. A prospective evaluation of a protocol for magnetic resonance imaging of patients with implanted cardiac devices. *Annals of internal medicine*. 2011;155:415-424