Magnetic resonance imaging in patients with cardiac implantable electronic devices in a cardio-oncology center

Mateusz Tajstra[1], Maciej Dyrbuś[1], Elżbieta Wojtynek[2], Adam Wojtaszczyk[1], Tomasz Rutkowski[3], Jacek T Niedziela[1], Aleksandra Błachut[1], Michał Jarząb[4], Sławomir Blamek[5], Anna Kurek[1], Jarosław Gorol[1], Mateusz Witek[1], Krzysztof Skladowski[3], Mariusz Gąsior[1], Barbara Bobek-Bilewicz[6]

[1]3rd Department of Cardiology, School of Medical Sciences in Zabrze, Medical University of Silesia, Katowice, Poland
[2]Department of Cardiology and Intensive Cardiac Care Unit, Regional Specialist Hospital No. 3, Rybnik, Poland
[3]1st Department of Radiation and Clinical Oncology, Maria Skłodowska-Curie National Research Institute of Oncology, Gliwice Branch, Gliwice, Poland
[4]Breast Cancer Unit, Maria Skłodowska-Curie National Research Institute of Oncology, Gliwice Branch, Gliwice, Poland
[5]Department of Radiotherapy, Maria Skłodowska-Curie National Research Institute of Oncology, Gliwice Branch, Gliwice, Poland
[6]Department of Radiology and Imaging Diagnostic, Maria Skłodowska-Curie National Research Institute of Oncology, Gliwice Branch, Gliwice, Poland

Correspondence to:
Mateusz Tajstra, MD, PhD,
3rd Department of Cardiology,
School of Medical Sciences
in Zabrze,
Medical University
of Silesia, Katowice,
Silesian Center for Heart Diseases,
SkłodowskiejCurie 9,
41–800 Zabrze, Poland,
phone: +48 32 373 38 60,
e-mail: mateusztajstra@wp.pl

DOI: 10.33963/KP.a2023.0080

Received:
December 5, 2022

Accepted:
January 17, 2023

Early publication date:
March 29, 2023

INTRODUCTION

Magnetic resonance imaging (MRI) has been for years contraindicated in patients with cardiac implantable electronic devices (CIEDs) due to the possibility of the occurrence of adverse events, such as acute depletion of battery voltage, changes in the lead parameters causing unsuccessful pacing or antiarrhythmic therapies, or acute device reset. However, patients with CIEDs often require diagnostics with MRI due to various causes. Despite the recommendations of scientific societies, such as the consensus document of the Heart Rhythm Society (HRS) and the recent European Society of Cardiology guidelines for cardiac pacing and cardiac resynchronization therapy, which recommend that physicians perform MRI in patients with CIEDs under specific conditions, this imaging modality is still rarely performed in patients with CIEDs, and often time from an initial assessment to MRI is prolonged, which can be critical, particularly in cancer patients, who require fast and accurate diagnostics [1, 2].

Therefore, across the globe, MRI scans in patients with CIEDs were initiated under strict surveillance of cardiac electrophysiologists according to the local prespecified protocols and in line with manufacturers' recommendations. In 2018, in a partnership between the 3rd Department of Cardiology of the Silesian Center for Heart Diseases and Maria Skłodowska-Curie National Research Institute of Oncology, Gliwice Branch, MRI exams in patients with various types of CIEDs were initiated [3]. This article aims to briefly summarize the characteristics of these patients as well as the immediate outcomes of the procedures.

METHODS

All patients referred for MRI due to any reasons underwent a screening visit, during which the eligibility of the patients' CIED system for MRI was assessed. In each patient, the type of device and leads were assessed, and the devices were interrogated. Both MRI-conditional and non-MRI-conditional devices were considered eligible for MRI. However, in the presence of either an epicardial, abandoned, or fractured lead, if the device was approaching elective replacement indicator, had been implanted in the previous 6 weeks, or there were any prior signs of the device malfunctions, the patient was disqualified from the procedure, pending reassessment after resolving those conditions.

On the day of the MRI scan, each patient had their device interrogated and programmed by an experienced cardiologist according to the HRS expert consensus on MRI in patients with CIEDs [1]. The programming of the device was at the discretion of the cardiologist, including the possible activation of the MRI-compatible modes. During each procedure, we continuously recorded the patient's oximeter oxygen saturation, noninvasive blood pressure, and electrogram, and a cardiologist, an MRI technician, and a nurse were present throughout the entire

MRI analysis. An external defibrillator was available on-site during every study. After completion of the MRI scan, the devices were interrogated and reprogrammed to the settings from the period before the MRI scan. The device software or hardware parameters, including variables indicating generator and lead functioning, were documented before and after MRI. Each patient was advised to undergo routine follow-up after 1–3 months in the patient's local referring center. However, the physicians were obliged to instruct the patient to report for follow-up after 1 week in the patient's local center if any of the following changes in device parameters occurred: pacing lead threshold increase by ≥1.0 V; P-wave or R-wave amplitude reductions by ≥50%; pacing lead impedance changes by ≥50 Ohm or shock lead impedance alterations by ≥5 Ohm. All scans were performed with the use of a 1.5T MRI Magnetom Aera scanner (Siemens AG, Munich, Germany).

Categorical variables were presented as absolute numbers and percentages, numerical as median with minimal and maximal values. The ethics committee's approval and patient informed consent were not required for this study.

RESULTS AND DISCUSSION

During the years 2018–2022, there were 122 patients with CIEDs, who were qualified for and underwent a total of 149 MRI studies in the presence of a cardiologist, as listed in Table 1. The majority of patients underwent either MRI of the brain (29.5%) or the abdominal/pelvic region (30.9% in aggregate). The most common type of CIED was a double-chamber pacemaker (52.3%), and the majority of the devices were Medtronic/Vitatron devices (54.4%). Notably, there was 1 patient with an implanted loop recorder and one patient with subcutaneous implantable cardioverter-defibrillator (ICD) who underwent an MRI scan. None of the procedures were associated with any programming alterations. Moreover, no immediate changes in either battery voltage, pacing threshold, or sensing were observed. In three patients, a change in high-voltage lead impedance by 5 Ohms, 6 Ohms, and 8 Ohms was observed, without any other alterations in device parameters.

The number of patients with malignancy and concomitant heart failure, or any other cardiac disease requiring the implantation of CIEDs grows each year. The prior calculations estimated that approximately 50%–75% of patients with a CIED could need an MRI scan in the lifetime of the device, which could potentially increase even further with constantly prolonged device longevity and wider adoption of MRI into diagnostic processes [4]. Nonetheless, in some MRI-equipped facilities, the presence of CIEDs is still considered a contraindication to performing MRI. Therefore, it is crucial to demonstrate that in the real-world setting, patients with CIEDs may undergo a safe MRI scan, which is often the most important diagnostic modality in the course of their disease.

Table 1. Characteristics of patients undergoing MRI under cardiologists' surveillance during the analyzed period

Demographics	
Female sex, n/n (% of all patients)	42/122 (34.4)
Age, years, median (min-max)	68 (16–90)
Region of MRI analysis	N (% of procedures)
Abdomen MRI	17 (11.4)
Brain MRI	44 (29.5)
Prostate MRI	29 (19.5)
Cardiac MRI	5 (3.6)
Spine MRI	8 (5.4)
Breast MRI	3 (2.0)
Chest MRI	3 (2.0)
Others	40 (26.8)
Type of CIED	N (% of procedures)
ICD-DR	12 (8.0)
ICD-VR	18 (12.1)
CRT	21 (14.1)
PM-DR	79 (53.0)
PM-VR	17 (11.4)
CIED manufacturers	N (% of procedures)
Medtronic/Vitatron	81 (54.4)
Biotronik	26 (17.4)
Boston Scientific	18 (12.1)
St. Jude/Abbott	24 (16.1)
Device characteristics	N (% of procedures)
Pacing dependency	34 (22.8)
Secondary prevention of SCD, of all ICD/CRT-D devices	6 (12.0)
MRI-conditional device	60 (40.3)

No events concerning device functioning, including hardware and software issues were reported in the device interrogation immediately after MRI

Abbreviations: CIED, cardiac implantable electronic device; CRT-D, cardiac resynchronization therapy-defibrillator; ICD-DR, double-chamber implantable cardioverter-defibrillator; ICD-VR, single-chamber implantable cardioverter-defibrillator; MRI, magnetic resonance imaging; PM-DR, double-chamber pacemaker; PM-VR, single-chamber pacemaker; SCD, sudden cardiac death

In order to facilitate easier access to MRI, the device manufacturers have introduced MRI-conditional devices, whose structure and design reduce the risk of system overheating or any other form of electromagnetic interference [5, 6]. Nonetheless, it should be noted that these devices are not completely prone to dysfunction during MR [7], and the presence of dedicated personnel, conversant with CIED programming is still recommended during the MRI scan. The 2021 European Society of Cardiology guidelines for cardiac pacing and cardiac resynchronization therapy recommend performing MRI in MRI-conditional devices provided that the manufacturers' guidelines are followed, while in the non-MRI-conditional devices, the examination should be recommended if no other alternative imaging methods are available and there are no epicardial, abandoned, or dysfunctional leads [2]. Similarly, the 2017 HRS Consensus on MRI and radiation therapy in patients with CIEDs recommends a rigorous structured approach in patients with both MRI-conditional and non-MRI-conditional devices [1].

Previously published data from other facilities are in line with our results. In a large, retrospective analysis of

more than 2100 MRI scans performed in patients with non-MRI-conditional devices, in only nine devices power-on resets were identified [8]. In another multicenter registry of non-MRI-conditional devices in patients who underwent nonthoracic MRI, in 1500 scans performed, no hardware failures were identified as far as a generator or lead were concerned if the device was programmed according to the prespecified protocol [9]. However, the cited evidence included also a long-term follow-up of the devices, which was not available in our analysis. Thus, it should be considered as a limitation of our study. Our results, as well as the cited literature, indicate that a structured, rigorously planned, and implemented MRI strategy under the surveillance of a cardiologist experienced in the interrogation and management of CIEDs enables a safe procedure, enhances the availability of imaging diagnostics in patients requiring MRI, in whom the scan is often crucial for diagnosis and monitoring of their diseases.

Article information

Conflict of interest: None declared.

Funding: None.

REFERENCES

1. Indik JH, Gimbel JR, Abe H, et al. 2017 HRS expert consensus statement on magnetic resonance imaging and radiation exposure in patients with cardiovascular implantable electronic devices. Heart Rhythm. 2017; 14(7): e97–e9e153, doi: 10.1016/j.hrthm.2017.04.025, indexed in Pubmed: 28502708.
2. Glikson M, Nielsen JC, Kronborg MB, et al. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy. Europace. 2022; 24(1): 71–164, doi: 10.1093/europace/euab232, indexed in Pubmed: 34455427.
3. Tajstra M, Blamek S, Skoczylas I, et al. Two professions against two killer diseases: the rationale, organization, and initial experience of a cardio-oncology service. Kardiol Pol. 2021; 79(2): 139–146, doi: 10.33963/KP.15674, indexed in Pubmed: 33146505.
4. Kalin R, Stanton MS. Current clinical issues for MRI scanning of pacemaker and defibrillator patients. Pacing Clin Electrophysiol. 2005; 28(4): 326–328, doi: 10.1111/j.1540-8159.2005.50024.x, indexed in Pubmed: 15826268.
5. Wilkoff BL, Bello D, Taborsky M, et al. Magnetic resonance imaging in patients with a pacemaker system designed for the magnetic resonance environment. Heart Rhythm. 2011; 8(1): 65–73, doi: 10.1016/j.hrthm.2010.10.002, indexed in Pubmed: 20933098.
6. Gimbel JR, Bello D, Schmitt M, et al. Randomized trial of pacemaker and lead system for safe scanning at 1.5 Tesla. Heart Rythm. 2013; 10(5): 685–691, doi: 10.1016/j.hrthm.2013.01.022, indexed in Pubmed: 23333721.
7. Krebsbach A, Dewland TA, Henrikson CA. Malfunction of an MRI-Conditional Pacemaker Following an MRI. HeartRhythm Case Rep. 2017; 3(2): 148–150, doi: 10.1016/j.hrcr.2016.11.007, indexed in Pubmed: 28491791.
8. Nazarian S, Hansford R, Rahsepar AA, et al. Safety of magnetic resonance imaging in patients with cardiac devices. N Engl J Med. 2017; 377(26): 2555–2564, doi: 10.1056/NEJMoa1604267, indexed in Pubmed: 29281579.
9. Russo RJ, Costa HS, Silva PD, et al. Assessing the Risks Associated with MRI in Patients with a Pacemaker or Defibrillator. N Engl J Med. 2017; 376(8): 755–764, doi: 10.1056/NEJMoa1603265, indexed in Pubmed: 28225684.