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Tamara Syrek-Jensen, JD
Director, Division of Items and Devices
Centers for Medicare and Medicaid Services
Office of Clinical Standards and Quality
Coverage and Analysis Group
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Mail Stop C1-09-06
Baltimore, MD 21244

Re: Proposed Decision Memo for Magnetic Resonance Imaging (MRI) (CAG-00399R4)

Dear Ms. Syrek-Jensen:

In July of 2017, on behalf of a group of experts in the field of MRI with an implanted cardiac device, we the undersigned submitted a formal request to revise the current policy regarding coverage of magnetic resonance imaging (MRI) for Medicare beneficiaries who have a non-MRI-conditional cardiac implantable electronic device (CIED). This category of a non-MRI-conditional device (CIED) includes a permanent pacemaker or implantable cardioverter-defibrillator (ICD) that is not approved by the Food and Drug Administration for MRI scanning (Please see the previous correspondence attached below).

Subsequently, the Centers for Medicare & Medicaid Services (CMS) published the "Proposed Decision Memo for Magnetic Resonance Imaging (MRI) (CAG-00399R4). In that memo, it was proposed that any MRI examination for patients with an implanted pacemaker, implantable cardioverter defibrillator, cardiac resynchronization therapy pacemaker, or cardiac resynchronization therapy defibrillator that **does not** have FDA labeling specific to use in an MRI environment would be covered **only** under the following conditions:

a. MRI field strength is ≤ 1.5 Tesla;
b. It has been ≥ 6 weeks since a patient's device implantation or any lead revision or surgical modification;
c. The patient is not pacemaker-dependent;
d. The implanted pacemaker, implantable cardioverter defibrillator, cardiac resynchronization therapy pacemaker, or cardiac resynchronization therapy defibrillator system has no fractured, epicardial, or abandoned leads;
e. The facility has implemented a checklist that includes the following:

- Patient assessment is performed to identify the presence of an implanted pacemaker, implantable cardioverter defibrillator, cardiac resynchronization therapy pacemaker, or cardiac resynchronization therapy defibrillator;
- Before the scan, benefits and harms of the MRI scan are communicated with the patient or the patient's delegated decision-maker;
- Prior to the MRI scan, the implanted pacemaker, implantable cardioverter defibrillator, cardiac resynchronization therapy pacemaker, or cardiac resynchronization therapy defibrillator is interrogated and programmed into the appropriate MRI scanning mode;
- A qualified physician, nurse practitioner or physician assistant with expertise with implanted pacemakers, implantable cardioverter defibrillators, cardiac resynchronization therapy pacemakers, or cardiac resynchronization therapy defibrillators must directly supervise;
- A discharge plan that includes before being discharged from the hospital/facility, the patient is evaluated and the implanted device is interrogated to detect and correct any abnormalities that might have developed during the MRI.

After a review of the proposed changes to the National Coverage Determination (NCD) contained within Decision Memo CAG-00399R4, we strongly believe that the following three exclusions are not supported by published data, and that these exclusions **should not** be included in the final version of the Decision Memo for MRI with an implanted cardiac device:

1. It has been ≥ 6 weeks since a patient's device implantation or any lead revision or surgical modification. **We request that this exclusion be removed from the Decision Memo, and that no exclusion is placed on a minimum time since lead or generator placement in the final Decision Memo. In our opinion, this exclusion is not supported by the available data or our cumulative clinical experience (please see below).**

2. The patient is not pacemaker-dependent; **We request that this exclusion regarding pacing-dependent patients be removed from the Decision Memo. In our opinion, this exclusion is not supported by the available data or our cumulative clinical experience (please see below).**

3. The implanted pacemaker, implantable cardioverter defibrillator, cardiac resynchronization therapy pacemaker, or cardiac resynchronization therapy defibrillator system has no fractured, epicardial, or abandoned leads; **We request that the exclusion for abandoned leads be removed from the Decision Memo. In our opinion, this exclusion is not supported by the available data or our cumulative clinical experience (please see below).**

Exclusion for a Post CIED Implant Waiting Period of Less Than 6 weeks

The CMS Memo CAG-00399R4 states that "Almost all studies reviewed excluded patients with recently implanted, revised, or modified leads. Investigators stated that this exclusion was due to lead dislodgements being more likely to occur in the immediate post-implantation period. The Canadian Heart Rhythm Society and Canadian Association of Radiologists consensus statement considers a recent CIED implant to be "red flags" for a CIED patient who is scheduled for MR scanning. As stated by that consensus statement and the HRS consensus statement, some CIED manufacturers recommend that a device with FDA labeling specific to use in an MRI environment be implanted > 6 weeks from time of MR imaging and a 6-week waiting period was adopted in clinical trials of PMs with FDA labeling specific to use in an MRI environment to avoid confusion as to whether a lead dysfunction was related to performance of the MRI scan. Only a few studies, including Nazarian, S (2011) and Friedman, H.L. (2013), provided limited observations regarding patients with MRI scans <42 days after CIED implant. While these studies reported no clinically significant differences in device function observed between patients scanned early or late after CIED implantation, the subsets with earlier scans were very small. Therefore, we propose to cover Medicare beneficiaries with a CIED without FDA-approved labeling for use in an MRI environment only when beneficiaries are ≥ 6 weeks since CIED implantation or any lead revision or surgical modification."

However, we believe that an exclusion based upon a minimum time since lead implantation is not supported by the available data, or our combined clinical experience.

Pacemaker and ICD leads do not contain ferrous metal components. Thus, exposure to a high-strength, external magnetic field should not result in displacement of a recently implanted cardiac lead. No study of outcomes after MRI with an implanted cardiac device has documented movement of a recently implanted cardiac lead, and no study has noted a correlation between adverse clinical events and the time since implantation of a cardiac lead after MRI.

In addition to the publications of Nazarian, S (2011) and Friedman, H.L. (2013) noted above, CMS has neglected to include and discuss the data obtained from the MagnaSafe Registry. In that study "Among patients who had undergone placement of a new generator or lead within 90 days before the MRI, there were no primary end-point events, and secondary end-point events were limited to a change in pacing lead impedance in 2 of 53 new pacemaker leads and in 1 of 27 new ICD leads." This data included two patients who underwent MRI of the brain on the day of pacemaker placement without adverse events.

In the 2017 HRS Expert Consensus Statement on Magnetic Resonance Imaging and Radiation Exposure in Patients with Cardiovascular Implantable Electronic Devices[3], it is stated that "It is reasonable to perform an MR scan immediately after implantation of a lead

or generator of an MR non-conditional CIED system if clinically warranted. [1,4,5,6,7]" The authors of the Expert Consensus Statement support the recommendation with the statement that "Limits have previously been placed on the minimum time between lead and generator implantation and MR imaging for patients with MR conditional CIEDs. Because lead dislodgements are more likely to occur in the immediate post-implantation period, a 6-week waiting period was adopted in clinical trials of MR conditional PMs to avoid confusion as to whether a lead dysfunction was related to performance of the MRI scan. In a single-center prospective cohort of 171 patients that included 8 patients with recently implanted systems (7–36 days), there were no differences in device function observed between patients scanned early or late after CIED implantation.[6] In the MagnaSafe Registry, there were 63 cases in which MRI was performed within 90 days of implant, 17 cases in which MRI was performed within 30 days of implant, and 5 cases in which MRI was performed within 7 days of implant; there was no correlation between changes in lead performance (sensing, pacing threshold, or impedance) and time from lead implantation.[1] These data support the feasibility of MRI in patients with recently implanted CIEDs."

Therefore, we request that no restriction be placed within the Final Decision Memo from CMS regarding coverage for MRI in patients with an implanted non-MR-conditional cardiac device based upon the time since lead or generator implantation.

Exclusion for Pacemaker-Dependent Patients

The CMS Memo, CAG-00399R4, states that "Electromagnetic interference (EMI) generated by the gradient magnetic field during MRI may be received by a CIED as a reset signal (Power on Reset, or PoR). This PoR could cause the CIED to revert to its factory default settings. For pacemaker-dependent patients with CIEDs programmed for asynchronous pacing used during MRI, the device may be reset to an inhibited mode. The evidence base, including studies by Higgins, J.V., et al. 2015 and Muehling, O.M., et al. 2014, observed occurrences of PoR which were at times associated with a decrease in heart rate during MRI. All devices functioned normally after completion of the MRI. Therefore, we are proposing to not include pacemaker-dependent patients under the covered population."

However, we believe that an exclusion based upon pacing-dependence is not supported by the available data, or our combined clinical experience.

The theoretical concerns of the CMS authors included in the Decision Memo CAG-00399R4 regarding the safety of MRI for pacing-dependent patients with an implanted cardiac device, are not supported by the clinical results of the MagnaSafe Registry[1], or the results of Nazarian, S., et al (2017)[2].

In the MagnaSafe Registry, for patients with a pacemaker or an ICD, pacing dependence was defined as having an intrinsic rhythm lower than 40 beats per minute or having symptoms of

presyncope or lightheadedness at a heart rate of 40 beats per minute or higher. In total, 282 patients, or 28.4% of the enrolled pacemaker patients were pacing-dependent. When MRI was performed in these pacing-dependent pacemaker patients, there were no losses of pacing capture noted.

Prior to the performance of MRI for patients with an implanted cardiac device, Nazarian, S, et al[2] reprogrammed the device "to an asynchronous pacing mode for patients who had an intrinsic heart rate of less than 40 beats per minute. An inhibited pacing mode was used for all other patients." In this population of 138 pacing-dependent patients, the authors reported no losses of capture.

The CMS authors state that "Power on Reset could cause the CIED to revert to its factory default settings. For pacemaker-dependent patients with CIEDs programmed for asynchronous pacing used during MRI, the device may be reset to an inhibited mode."

It was noted in the MagnaSafe Registry[1], that "in six cases (five patients), the patient had partial generator electrical reset; in all six cases, the patients had pacemakers that had been implanted 5.7 to 9.7 years before the MRI (Table S5 in the Supplementary Appendix). Settings in the device memory that were reset included patient and device or lead identification information. **No appropriately screened and reprogrammed device underwent a full electrical reset**." The low rate of partial electrical reset and the lack of full electrical reset were due to the protocol exclusion of patients with a pacemaker (or ICD) generator with a battery that was near the end of its battery life (with a device interrogation display that read "elective replacement indicator")."

In addition, within the MagnaSafe Registry pacing-dependent patients with an ICD were excluded, because "not all such patients had a device that was capable of providing pacing function while allowing for inactivation of tachycardia therapy." The authors of the MagnaSafe Registry add the specific recommendation that their "method should not be applied to pacing-dependent patients with an ICD unless independent programming of the bradycardia and tachycardia functions is possible."

In the 2017 HRS Expert Consensus Statement on Magnetic Resonance Imaging and Radiation Exposure in Patients with Cardiovascular Implantable Electronic Devices[3], it is recommended "that for the patient with an MR non-conditional CIED who is pacing-dependent to program their device to an asynchronous pacing mode with deactivation of advanced or adaptive features during the MRI examination, and the pacing rate should be selected to avoid competitive pacing." [1,5,7,8,9] In this Expert Consensus Statement, there is no exclusion for patients who are pacing-dependent.

Remember, that in this Consensus Statement, as well as in all published studies, "It is recommended that continuous MR conditional ECG and pulse oximetry monitoring be used

and observed while an MR non-conditional CIED is reprogrammed for imaging, and continued until baseline or until other clinically appropriate CIED settings are restored."

Therefore, we request that no restriction be placed in the Final Decision Memo from CMS regarding coverage for MRI with an implanted cardiac device based upon pacing-dependence in patients with a non-MR-conditional cardiac device.

Exclusion for Fractured, Epicardial, or Abandoned Leads

The CMS Memo, CAG-00399R4, states that "The HRS consensus statement concluded that, 'At the present time, however, there are insufficient data to comment on the safety of MRI performance with abandoned, epicardial, or fractured leads. The Canadian Heart Rhythm Society and Canadian Association of Radiologists consensus statement states that, "MR scanning is absolutely contraindicated" in the patients with fractured, epicardial, or abandoned leads. Postsurgical temporary epicardial leads that have been partially removed are not considered to be abandoned pacing leads.' Patients with fractured, epicardial, or abandoned leads are frequently excluded from studies of CIEDs in the MRI environment. There were no MRI studies specifically on safety and outcomes of these patients that met our inclusion criteria. There is a paucity of evidence to support MRI scans in patients with fractured, epicardial, or abandoned leads. Therefore, we propose not to include patients with these lead conditions under the covered population for those with CIEDs."

However, we believe that an absolute exclusion based upon the presence of an abandoned lead is not supported by the available data, or our combined clinical experience.

In the MagnaSafe Registry, patients with an abandoned cardiac lead were excluded from study enrollment. However, this exclusion was based on the ability to collect data. An abandoned lead could not be interrogated before and after the MRI procedure to assess a change in lead function as judged by pacing thresholds, measured electrical activity, or a change in lead impedance. The exclusion was not based upon data that suggested a risk to the patient or the device.

Padmanabhan, D., et al[10] evaluated the safety of magnetic resonance imaging in patients with non-MRI-conditional pacemakers and defibrillators who also had abandoned leads. Between 2008 and 2017, 80 patients with 90 abandoned leads underwent 97 MRI examinations. The authors found no evidence of myocardial injury, as measured by paired cTnT in patients who underwent MRI with an abandoned cardiac lead. The authors concluded that the "risk of MRI with abandoned leads appears low, suggesting a favorable risk-benefit profile in patients with CIEDs and abandoned leads who are considered for MRI."

The performance of MRI in a patient with an implanted cardiac device and an abandoned lead should remain a clinical decision made by the treating physician in collaboration with

an electrophysiologist or cardiologist with cardiac device expertise. If MRI is determined to be the imaging modality of choice for a patient with an abandoned lead in the opinion of the treating physician, then coverage should be provided for that patient.

Therefore, we request that no restriction be placed in the Final Decision Memo from CMS regarding the presence of an abandoned cardiac lead for patients with an MR non-conditional device who undergo MRI.

In summary, based upon the available published data and our cumulative clinical experience, we believe very strongly, and request that the following exclusions **be removed** from the Final Decision Memo regarding coverage for:

- Patients with a non-MR-conditional device and or cardiac leads placed within 6 weeks
- Pacing-dependent patients with a non-MR-conditional pacemaker or ICD
- Patients with an abandoned cardiac lead, as an absolute exclusion

Thank you for your consideration of our request. If you have any questions or require additional information, please feel free to contact Dr. Russo by phone at 858-886-7595, or by email at russo@scripps.edu; Dr. Kramer by email at dkramer@bidmc.harvard.edu, or Dr. Nazarian by email at saman.nazarian@uphs.upenn.edu .

Sincerely,

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July 4, 2017

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Re: Formal Request for Reconsideration of the National Coverage Determination (NCD) for Magnetic Resonance Imaging (MRI) to revise the Contraindication for Non-MRI-Conditional Cardiac Pacemakers in Patients Not Enrolled in a Prospective Clinical Study (Chapter 1, Section 220.2.C.1 in the NCD Manual; other diagnostic tests §1861(s)(3))

Dear Ms. Syrek-Jensen:

On behalf of the undersigned individuals, and professional organizations, we are writing to formally request a revision of the current policy regarding coverage of magnetic resonance imaging (MRI) for Medicare beneficiaries who have a non-MRI-conditional cardiac implantable electrical device (CIED), which includes a permanent pacemakers or implantable cardioverter-defibrillator (ICD) (i.e., not approved by the Food and Drug Administration for MRI scanning). As you are aware, it is stated in the current Medicare National Coverage Determinations Manual (NCD), that payment for an MRI examination "will be covered by Medicare when studied in a clinical study under § 1862(a)(1)(E) (consistent with § 1142 of the Act) if the study meets the criteria" included in Decision Memo for Magnetic Resonance Imaging (MRI) (CAG-00399R2)[1].

A previous request by one member of our group to the Centers for Medicare & Medicaid Services (CMS) for a revision in the NCD language resulted in Decision Memo CAG-003999R2, which was published in February 2011. In the Decision Memo it was stated that "CMS believes that the evidence is promising although not yet convincing that MRI will improve patient health outcomes if certain safeguards are in place to ensure that the exposure of the device to an MRI environment adversely affects neither the interpretation of the MRI result nor the proper functioning of the implanted device itself. We believe that specific precautions could maximize benefits of MRI exposure for beneficiaries enrolled in clinical studies designed to assess the utility and safety of MRI exposure." We now feel strongly feel that the weight of the published literature in this field provides "convincing evidence" that, with appropriate precautions, MRI can be performed with minimal risk in Medicare beneficiaries with CIEDs, that the resulting images are interpretable, and that health outcomes for Medicare beneficiaries are improved. This letter outlines our rationale.

A. MagnaSafe Registry

A multicenter study with the goal of determining the frequency of cardiac device–related clinical events and device setting changes among patients with a non–MRI-conditional device who underwent nonthoracic MRI at a field strength of 1.5 tesla began enrollment in 2009 (The MagnaSafe Registry[2]). The MagnaSafe Registry experimental protocol was written after consultation with personnel at the Center for Devices and Radiological Health of the US Food and Drug Administration (FDA), and an investigational device exemption (IDE) was obtained for the purpose of data collection and adverse event reporting. The MagnaSafe Registry continued after publication of Decision Memo CAG-003999R2. It was subsequently noted in Decision Memo CAG-00399R3 (July 2011), that in the opinion of the representatives of the CMS Coverage and Analysis Group, that they "believed that the MagnaSafe registry appears to meet the CED (coverage with evidence development) requirement."[3]

The results of the MagnaSafe Registry were published in February 2017.[4] In this study, a total of 1000 pacemaker cases and 500 ICD cases with non-MRI-conditional systems were enrolled in centers in the United States. The MRI examinations were clinically indicated in the opinion of the patient's ordering physician, and MRI scans of the chest (thoracic MRI including cardiac imaging and thoracic spine imaging) were excluded from study entry. Cardiac devices were interrogated before, and after MRI with the use of a standardized protocol, and the devices were appropriately reprogrammed before the MRI examination. The primary end points of the study were death, generator or lead failure, induced arrhythmia, loss of capture for pacing-dependent patients or electrical reset during the examination. The secondary end points were pre-determined changes in device settings.

In this study, no deaths, lead failures, losses of capture in pacing-dependent patients, or ventricular arrhythmias occurred during MRI. One ICD generator could not be interrogated after MRI and required immediate replacement; the device had not been appropriately programmed per protocol before the MRI. However, a similar event may have occurred with an MRI-conditional ICD, had such a device not been appropriately programmed prior to the MRI examination. Six cases of self-terminating atrial fibrillation or flutter and six cases of partial electrical reset were observed. Changes in lead impedance, pacing threshold, battery voltage, and P-wave and R-wave amplitude exceeded prespecified levels in a small number of cases. Repeat MRI examinations were not associated with an increase in adverse events. This study demonstrated that patients with a non–MRI-conditional pacemaker or ICD could undergo clinically indicated nonthoracic MRI at 1.5 tesla, without risk to the patient or device, when the patient was appropriately screened, and the device was reprogrammed in accordance with the prespecified protocol.

B. Additional Literature

Prior to the publication of the MagnaSafe Registry results, Nazarian, et al[5], published "A Prospective Evaluation of a Protocol for Magnetic Resonance Imaging of Patients With Implanted Cardiac Devices." The purpose of this study was to define the safety of a protocol for MRI at a field strength of 1.5 T in patients with an implanted cardiac device. In this study, patients with either a non-MRI-conditional pacemaker or defibrillator underwent a total of 555 MRI scans; 18% of these scans included the heart or thoracic spine.

The results of this study included 3 cases in which the device reverted to a transient back-up programming mode without long-term effects, and ventricular sensing and atrial and ventricular lead impedances were reduced by a small amount immediately after MRI. At long-term follow-up, decreased ventricular sensing, decreased ventricular lead impedance, increased ventricular capture threshold, and decreased battery voltage were noted. However, the observed changes did not require device reprogramming or replacement.

In addition to the 2,055 cases enrolled in the two studies noted above, an additional 1,888 cases were reported in several smaller studies examining the risk associated with MRI in patients with a non-MRI-conditional implanted device[4-24] (Table 1). In these studies, the authors reported varying effects on cardiac device settings. Overall, MR scanning was performed safely; electrical resets were rarely seen and were successfully reprogrammed after the procedure. Pacing thresholds were noted to increase and decrease, but rarely required a change in programming.

It was also stated in Decision Memo CAG-003999R2 that "CMS believes that the evidence is promising although not yet convincing that MRI will improve patient health outcomes if certain safeguards are in place to ensure that the exposure of the device to an MRI environment" does not adversely affect "the interpretation of the MRI result…" Recently, Mukai et al[25] presented "Does the presence of an implanted cardiac device adversely affect the image quality of clinically indicated magnetic resonance imaging at 1.5t?" The authors reported the imaging results of 1000 consecutive clinically indicated MRI examinations at 1.5 tesla performed in 569 patients with an implanted pacemaker of defibrillator. Device-related imaging artifacts were reported in 1.0% of non-cardiac scans, but none of the 976 non-cardiac MRI studies "contained an artifact that adversely affected image quality with the requirement for an alternate imaging modality."

Lastly, Strom et al[42] described a case series of 189 MRI examinations performed in 123 patients. In this series 98.4% of scans were deemed to be interpretable. Using a pre-specified adjudication system for determining the clinical utility of MRI, nearly 80% of MRI examinations that met the requirement of an interpretable scan, also led to a change in treatment or diagnosis or guided a subsequent procedure.

C. Professional Society Guidelines

In May 2017 Indik, et al[26], published the "2017 Heart Rhythm Society (HRS) expert consensus statement on magnetic resonance imaging and radiation exposure in patients with cardiovascular implantable electronic devices," which is intended to help health care providers involved in the care of adult (and pediatric) patients with cardiac implantable electronic devices who are to undergo MRI. This document addresses the recommended procedures for MRI in patients with MRI-conditional and non-MRI-conditional pacemakers and implanted defibrillators. Regarding the management of patients with an non-MRI-conditional device undergoing an MRI examination, it is stated that: "It is reasonable for patients with an non-MRI-conditional system to undergo MR imaging if there are no fractured, epicardial, or abandoned leads; the MRI is the best test for the condition; and there is an institutional protocol and a designated responsible MR physician and CIED physician."

It should be noted that the HRS consensus statement[26] was developed in collaboration with and endorsed by the American College of Cardiology (ACC), American College of Radiology (ACR; endorsement pending), American Heart Association (AHA), American Society for Radiation Oncology (ASTRO), Asia Pacific Heart Rhythm Society (APHRS), European Heart Rhythm Association (EHRA), Japanese Heart Rhythm Society (JHRS), Pediatric and Congenital Electrophysiology Society (PACES), Brazilian Society of Cardiac Arrhythmias (SOBRAC), and Latin American Society of Cardiac Stimulation and Electrophysiology (SOLAECE) and in collaboration with the Council of Affiliated Regional Radiation Oncology Societies (CARROS).

D. Role of MRI in Clinical Medicine

Over the past decade, magnetic resonance imaging has become the imaging modality of choice for the evaluation of many, if not most diseases of the brain, spinal cord, and musculoskeletal system. Approximately 2-3 million people in the United States (many of them Medicare beneficiaries) have a non-MRI-conditional cardiac pacemaker or implantable cardioverter-defibrillator (ICD).[5] It is predicted that at least half of these patients will have a clinical indication for MRI during their lifetime after device implantation.[27] Improved access to MRI for Medicare beneficiaries with non-MRI-conditional pacemakers and ICDs will improve health outcomes. For example, MRI has been proven to be superior to computed tomography (CT) for the evaluation of

- Acute ischemic stroke[28]
- Detection of multiple sclerosis lesions.[29]
- Acute intracerebral hemorrhage[30]
- Detection of dysplastic hepatic nodules and early hepatocellular carcinoma[31,32]
- Whole-body imaging in patients with metastatic breast cancer[33]

In addition, Appropriateness Criteria from the American College of Radiology[34] rates MRI higher than CT for clinical decision-making in patients for:

- Breast Cancer Screening in high-risk women with a BRCA gene mutation and their untested first- degree relatives, women with a history of chest irradiation between the ages of 10–30, and women with 20% or greater lifetime risk of breast cancer
- Abdominal imaging with a liver lesion for initial characterization of an indeterminate, >1 cm lesion on initial imaging with ultrasound, and a normal liver
- Brain imaging in the evaluation of Alzheimer's disease, frontotemporal dementia, dementia with Lewy bodies, vascular dementia, Creutzfeld-Jakob or other prion mediated dementia, normal pressure hydrocephalus, neurodegeneration with brain iron accumulation, and Parkinsonian syndrome
- Brain imaging for patients with acute or chronic headache
- Brain imaging for patients with single or multiple focal neurologic deficits, of subacute onset, with progressive or fluctuating symptoms
- Brain imaging for patients with a suspected, or previously treated primary or metastatic brain malignancy
- Brain imaging for patients with seizures and epilepsy for the purpose of surgical planning, and for the evaluation of new onset seizures with or without head trauma.
- Brain imaging for patients with acute or subacute ataxia without head trauma
- Imaging of the orbits for patients with sudden non-traumatic onset of painless or painful visual loss.
- Imaging of the lumbar spine with acute, subacute, or chronic low back pain or radiculopathy

Therefore, the use of CT rather than MRI for patients with a non-MRI-conditional pacemaker or ICD may lead to an incorrect diagnosis, and possibly inappropriate, or incomplete therapy in many disease states.

In 2011, the FDA approved the first MRI-conditional pacemaker generator-and-lead for marketing in the United States (Revo MRI SureScan pacing system, Medtronic, Inc.).[35,36] Since that time, at least 13 generator-and-lead systems from four manufacturers have received FDA approval as an MRI-conditional system. Although it has been suggested that previously implanted non-MRI-conditional generators and leads may be removed and then replaced to allow for MRI, the potential risks from such procedures are much greater than those associated with MRI with an implanted non-MRI-conditional device. The rate of major complications among patients undergoing generator replacement with or without the placement of an additional transvenous lead was 4 to 15% in a prospective registry.[37] In addition, single-center and multicenter studies have shown a rate of major complications (including death and tamponade) associated with elective laser-assisted lead extraction that is in the range of 0.4 to 2%.[38-41] These results strongly suggests that device removal and replacement are unlikely to be safer than proceeding with scanning for patients with a non-MRI-conditional pacemaker or an ICD who require an MRI examination.

E. Requested Coverage Modifications

We feel the results of the MagnaSafe registry as well as the many studies that have examined the risk of MRI in patients with a non-MRI-conditional device, and have been published since the last request to change the NCD, provide sufficient evidence to demonstrate that MRI at a field strength of 1.5 tesla can be performed with minimal risk for patients who have a non-MRI-conditional pacemaker or ICD, when the patients are properly monitored and the device is appropriately reprogrammed before the examination following a protocol designed to minimize adverse events to patients and their devices.

Thus, we request that the current Medicare National Coverage Determination language be modified to allow coverage for Medicare beneficiaries with non-MRI-conditional pacemakers or ICDs who undergo MRI at a field strength of 1.5 tesla without the requirement for entry into a research study, when there is a strong clinical indication for the MRI examination, with no acceptable alternative imaging modality, and the patient is appropriately monitored. We further request that the language in section 220.2, section C.1; other diagnostic tests §1861(s)(3) in the National Coverage Determination be revised to remove the requirement for enrollment "in clinical studies designed to assess the utility and safety of MRI exposure" and to remove the requirements for coverage with evidence development. We suggest that the language be revised to read as follows:

"**An MRI procedure for patients (Medicare beneficiaries) with a non-MRI-conditional pacemaker or ICD will be covered if the examination is performed in accordance with the 2017 Heart Rhythm Society expert consensus statement on magnetic resonance imaging and radiation exposure in patients with cardiovascular implantable electronic devices (Indik, et al[26]).**" **The recommendations in that document include the following*:**

1. It is reasonable for patients with a non-MRI-conditional CIED system to undergo MR imaging if there are no fractured, epicardial, or abandoned leads; MRI is the best test for the condition; and there is an institutional protocol and a designated responsible MR physician and CIED physician.
2. It is reasonable to perform an MR scan immediately after implantation of a lead or generator of a non-MRI-conditional CIED system if clinically warranted.
3. For patients with a non-MRI-conditional CIED, it is reasonable to perform repeat MRI when required, without restriction regarding the minimum interval between imaging studies or the maximum number of studies performed.
4. It is recommended for the patient with a non-MRI-conditional CIED that device evaluation be performed immediately pre- and post-MRI with documentation of pacing threshold(s), P- and R-wave amplitude, and lead impedance using a standardized protocol.

5. A defibrillator/monitor (with external pacing function) and a manufacturer-specific device programming system should be immediately available in the holding area adjacent to the MR scanner room while an Non-MRI-conditional CIED is reprogrammed or imaging.
6. It is recommended that continuous MR conditional ECG and pulse oximetry monitoring be used while a Non-MRI-conditional CIED is reprogrammed for imaging.
7. It is recommended that personnel with the skill to perform advanced cardiac life support, including expertise in the performance of CPR, arrhythmia recognition, defibrillation, and transcutaneous pacing, accompany the patient with an Non-MRI-conditional CIED for the duration of time the patient's device is reprogrammed, until assessed and declared stable to return to unmonitored status.
8. For patients with a Non-MRI-conditional CIED who are pacing-dependent (PM or ICD), it is recommended that: a) Personnel with the skill to program the CIED be in attendance during MR scanning. b) A physician with the ability to establish temporary transvenous pacing be immediately available on the premises of the imaging facility. c) A physician with the ability to direct CIED programming be immediately available on the premises of the imaging facility.
9. For patients with a non-MRI-conditional CIED who are not pacing-dependent, it is recommended that: a) Personnel with the skill to program the CIED be available on the premises of the imaging facility. b) A physician with the ability to direct CIED programming be available on the premises of the imaging facility.
10. It is recommended that for the patient with a non-MRI-conditional CIED who is pacing-dependent to program their device to an asynchronous pacing mode with deactivation of advanced or adaptive features during the MRI examination, and the pacing rate should be selected to avoid competitive pacing.
11. All tachyarrhythmia detections for patients with an ICD should be disabled prior to MRI.
12. The MR-responsible physician who is accountable for overseeing the safety of the MRI environment, including the administration of any medication and/or contrast agents (if applicable), should be made aware of the presence of a patient with an Non-MRI-conditional CIED.
13. It is recommended that ECG and pulse oximetry monitoring be continued until baseline or until other clinically appropriate CIED settings are restored for patients with a Non-MRI-conditional CIED.
14. All resuscitative efforts and emergency treatments that involve the use of a defibrillator/monitor, device programming system, or any other MRI-unsafe equipment should be performed after moving the patient outside of Zone 4.
15. For a patient with a Non-MRI-conditional CIED who is not pacing-dependent, it is reasonable to program their device to either a non-pacing mode (OVO/ODO) or to an inhibited mode (DDI/VVI), with deactivation of advanced or adaptive features during the MRI examination.
16. It is reasonable to program patients with a Non-MRI-conditional CRT device who are not pacing-dependent to an asynchronous pacing mode (VOO/DOO) with

deactivation of advanced or adaptive features during the MRI examination, and with a pacing rate that avoids competitive pacing.

17. For patients with a Non-MRI-conditional CIED, it is reasonable to schedule a complete follow-up CIED evaluation within 1 week for a pacing lead threshold increase ≥1.0 V, P-wave or R-wave amplitude decrease ≥50%, pacing lead impedance change ≥50 Ω, and high-voltage (shock) lead impedance change ≥5 Ω, and then as clinically indicated.

(*The recommendations above, #1-17 pertaining to "Recommendations for the Decision to Perform an MRI on Patients with an MR Non-conditional CIED", are provided in the section above without alteration from Indik, et al.[26])

Thank you for your consideration of our request. If you have any questions or require additional information, please feel free to contact either Dr. Russo by phone at 858-886-7595, or by email at russo@scripps.edu; and/or Dr. Kramer by email at dkramer@bidmc.harvard.edu.

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Table 1: Literature regarding the management of patients with an non-MRI-conditional device who are undergoing MRI
(Adapted with permission from Indik, JH, et al[26])

Study author and Year	Study type and size	Inclusion criteria	Endpoints	Findings	Outcomes*	Statistics†	Limitations
Martin et al[6] 2004	Single center, prospective cohort N = 54 patients, 62 MR scans	Included cardiac, vascular and general MR studies, no restrictions on PM type but PM-dependent excluded	Pacing threshold post-MRI evaluated for "any change" or "any significant change" Any significant change defined as change >1 voltage or pulse width increment/decrement	A total of 9.4% of leads had significant changes, with 1.9% requiring change in programmed output, but unrelated to cardiac chamber, anatomic location, peak SAR, or time from implant to MR scan	No adverse outcomes, patient symptoms and ECG changes minor and did not require cessation of MRI	Logistic regression for peak SAR, chi-squared or Fisher exact for 2×2 contingency testing	Single center, only immediate post-MRI PM evaluation performed
Sommer et al[7] 2006	Single center, prospective cohort N = 82 patients, 115 MR scans	PM patients who were not dependent, MR scans not of thoracic region, urgent need for MR scan, Medtronic PMs manufactured 1993–2004, with stable device parameters	Change in pacing threshold clinically significant if ³ 1V	Pacing threshold increased pre- to post-MRI (P = .017), and clinically significant in 3.1% of leads (95% CI 1.1–6.6%), and in 2 leads increase in threshold detected at follow-up at 3 months Electrical reset occurred after 7 scans Troponin increased in 4 of	No inhibition of pacing or arrhythmia observed and scans performed safely PMs with electrical reset all programmed back to pre-scan parameters No leads required change in output to maintain function	Mixed repeated-measures regression analysis of threshold and impedance data, with covariates for cardiac chamber, timing of evaluation (pre, post, 3-month follow-up)	Single center Medtronic only

				114 scans, and in one case rise of troponin associated with significant change in threshold, but overall no significant increase in troponin (P = .0693)			
Nazarian et al[8] 2006	Single center, prospective cohort N = 55 patients, 31 PM 24 ICD, 68 MR scans	Patients included if no imaging alternative and could be pacing-dependent Excluded if <6 weeks from implant, nontransvenous leads, abandoned leads	Change in PM parameters from pre- to immediate post- and long-term follow-up	N = 12 pacing-dependent No inappropriate inhibition or pacing	No significant differences in amplitude, impedance, threshold from pre-scan to immediate post-scan or to long term f/u (median 99 days)	Paired Student t test to compare immediate and long term parameters	Single center
Pulver et al9 2009	Single center, prospective case series of adult and pediatric patients with congenital heart disease N = 8 patients, with N = 11 MR scans	Could have epicardial leads Not pacing-dependent and no abandoned leads	Safety Lead parameters	Average age 16.5 ± 9.2 years, and 5 under age 16 No inappropriate pacing or significant change in parameters noted pre- to post-MR scan	9 epicardial leads included Exams performed safely Long-term follow-up data available on 6 patients with no clinically important changes seen	Paired t tests to compare pacing parameters pre- and post-MR	Small case series
Burke et al[10] 2010	Single center, prospective cohort N = 38 patients, 92 MR scans	Indication for MR would result in significant clinical impact	Device parameters including DFTs immediate post MR and at 3-month follow up	N=13 PM-dependent, N = 11 not PM-dependent, N = 10 ICD patients, N	No device circuitry damage, programming alterations, no electrical resets, inappropriate	Paired t test and Wilcoxon rank sum test	Single center

				= 4 CRT patients	shocks, failure to pace or changes in sensing, pacing, or defibrillation threshold, including patients with multiple MR scans No change in device parameters at 3-month follow-up		
Buendia et al[11] 2010	Single center, prospective cohort N = 33 patients PPM 28 ICD 5	MR clinically essential	Safety Lead parameters	N = 28 with PMs, N = 5 with ICDT Noted: temporary communication failure in two patients; Sensing errors during imaging in two patients Safety signal generated in one PM at the maximum magnetic resonance frequency and output level	No technical restrictions on imaging or any permanent change in CIED performance, no clinical complications		Small case series
Cohen et al[12] 2012	Single center, retrospective cohort that underwent MR and prospective (control) cohort that did not undergo MR	All patients with permanent CIEDs who underwent clinically necessary MR scans from 2006–2009 Control group recruited from	Primary endpoints: death during MR, device or lead failure requiring immediate replacement, induced atrial or ventricular arrhythmias during	Pacer dependence: 27% in MR group, 16% in control group No significant change between MR and control groups for battery	No deaths, device failures, generator/lead replacements, loss of capture, or electrical reset	Linear mixed model analyses to compare MR and control groups for CIED parameters, adjusting for type of device and PM dependence	Retrospective MR cohort, single center

	Retrospective cohort: N = 109 patients, with N = 125 clinically indicated MR scans Prospective cohort: N = 50 patients with CIED	2008–2009 Underwent two interrogations one hour apart	MR, loss of PM capture, electrical reset Secondary endpoints: battery voltage decrease of ³ 0.4 V, pacing lead threshold increase of ³ 0.5 V at 0.4 ms pulse width, P-wave amplitude decrease ³ 50%, R-wave amplitude decrease ³ 25%, lead impedance change ³ 50 W, high voltage lead impedance change ³ 3W	voltage, P-wave amplitude, R-wave amplitude, or high voltage impedance Small mean decrease in LV threshold in MR group and small mean increase in control group noted Significant difference seen in MR group vs. control for lead impedance (P = .01), but not clinically important			
Strach et al[13] 2010	Single center, prospective cohort N = 114 patients with scans performed at 0.2 Tesla, including PM-dependent and abandoned leads	Urgent clinical need for MR scan Implants at least 3 months prior to scan with stable pacing parameters Excluded ICD	Evaluation pre- and post-MR	No induction of arrhythmias or inhibition of pacing, and no statistically significant changes in lead impedance, pacing threshold, or battery voltage. In no patient was a pacing threshold over 0.5 V observed	No adverse effects; MR at low field strength appeared to be safe and feasible	Wilcoxon signed rank test to compare pre- and post-MR parameters	Number of patients with abandoned leads or details not provided
Nazarian et al[5] 2011	Single center, prospective cohort N = 438	Consecutively enrolled from 2003–2010 Included PM-	Device function at immediate and long-term follow up, safety	Power-on reset occurred in 0.7% thoracic imaging, associated with decreased	MR performed safely Changes in device variables did not	Wilcoxon signed rank test	Single center

	patients, with N = 555 MR scans	dependent patients implanted >6 weeks prior to MR scan ICDs Excluded abandoned or epicardial leads Excluded ICD patients who were pacing-dependent		(compared to nonthoracic) acute RV ($P = .005$) and long-term RV R-wave amplitude ($P = .009$) Small decreases in device parameters seen but not clinically important immediate post-MR: RV amplitude ($P < .001$), atrial impedance ($P < .001$), RV impedance ($P < .001$), LV impedance ($P = .002$), battery voltage ($P < .001$) Small decreases in device parameters but not clinically important in long-term follow-up: RV amplitude ($P = .004$), RV impedance ($P = .044$), RV threshold ($P = .12$), battery voltage ($P < .001$)	require device revision or reprogramming		
Muehling et al[14] 2014	Single center prospective N = 356 patients, cranial MRI	PM patients needing urgent cranial MRI, included pacing-dependent patients, PMs implanted at least	Evaluation of pacing parameters pre-, immediate, post-MR scan and follow-up at 2 weeks, and 2,6, and 12 months	No immediate or late PM dysfunction, no increase in troponin within 12 hours Programmed	No significant changes in device parameters (sensing, impedance or pacing capture threshold) up to 12	Paired Wilcoxon rank sum test for continuous variables, Kruskal-Wallis for categorical variables	Single center, Cranial MRI only PM patients only

		2 months prior to scan; excluded epicardial or fractured lead; enrolled from 2004–2012	after scan Measurement of troponin 12 hours post-scan	parameters unchanged, data for threshold, sensing, impedance did not change significantly, with 19 patients having a maximum increase of 0.4 V in threshold seen	months	Pre- and post-scans compared by ANOVA	
Russo et al[4] 2017	Multicenter prospective registry N = 1000 PM cases (848 patients), and N = 500 (428 patients) ICD cases	Nonthoracic MR scans at 1.5 T Excluded patients with CIEDs implanted before 2002 Excluded ICD patients that were pacing-dependent	Primary outcomes: death, generator or lead failure that required immediate replacement, loss of capture, new onset arrhythmia during scan, partial or full electrical reset Secondary outcomes: decrease in battery voltage ³ 0.4 V, increase in pacing threshold ³ 0.5 V at 0.4 ms, decrease in P-wave ³ 50%, decrease in R-wave ³ 25%, increase/decrease in lead impedance ³50 Ω, increase/decrease in shock impedance³ 3 Ω	P wave: ≥50% decrease in .9% of PMs, 0.3% of ICDs R wave: ≥50% decrease in no PMs and 0.2% of ICDs Pacing threshold: ≥0.5 V in 0.7% of PMs, 0.8% of ICDs Lead impedance: ≥50 Ω in 3% of PMs, 4% of ICDs Repeat scanning performed in 22.6% of PMs and 18% of ICDs, with median interval between scans of 153 days for PM patients, 91 days for ICD patients	No deaths, lead failures, losses of capture or ventricular arrhythmias during MRI 5 patients had atrial fibrillation and one atrial flutter during MRI One ICD generator required replacement because it had not been programmed appropriately for scanning 6 partial electrical resets	95% CIs calculated for observed proportions of binary outcomes	Thoracic MRI excluded, also only small number of CRT devices

Junttila et al[15] 2011	Single center, prospective case series N = 10 ICD patients who underwent 3 serial cardiac MR scans	Excluded pacing-dependent patients	Evaluation of device parameters pre- and post-MR and at follow-up and 3, 6, and 12 months	Median follow-up 370 days	No adverse effects with serial MR scans No differences in pacing capture threshold, lead or high voltage lead impedance, or battery voltage, and no ICD dysfunction	Student *t* test and Mann-Whitney test	Small series, single center; troponin/cardiac biomarkers not measured
Boilson et al[16] 2012	Single center, prospective cohort N = 32 patients with 46 MR scans	Not pacing-dependent, with PM (excluded ICD), implanted at least 90 days prior to scan	Safety, lead parameters, cardiac enzymes	No significant change in battery voltage, sensed P/R waves, pacing thresholds, impedance immediately after MR or at 1 month follow-up No increase in cardiac enzymes PVCs noted in one patient	Power-on reset occurred in 5 scans (5 patients), more frequent with Medtronic Kappa No adverse clinical events	Fisher exact test, Pearson chi-squared tests for categorical values ANOVA for continuous variables	MR scan of head (N = 35) and spine (12 cervical, 7 thoracic, 5 lumbar)
Del Ojo[17] et al 2005	Prospective, single center, case series N = 13 patients, undergoing MR scan at 2 Tesla 1999–2001	Not pacing-dependent	Safety Lead parameters	No significant differences in sensing, stimulation, threshold, or impedance pre- and post-MR scan	No PM inhibition, asynchronous pacing, or inappropriate rapid pacing occurred	Student *t* test	Small case series, St. Jude PM only

Gimbel et al[18] 2005	Prospective cohort with substudy of PM-dependent patients N = 10 patients with 11 MR scans from 1994–2004	PM-dependent No chest or abdominal MR scans	Safety Lead Parameters pre-, post-MR scan, and at 3 months	No PM malfunction, pauses, or rapid pacing No power-on resets No clinically important change in pacing parameters	One patient with a Y adaptor in system	Not provided	Small series
Mollerus et al[19] 2008	Single center, prospective cohort N = 37 patients with 40 MR scans	Not pacing-dependent PM, ICD, or CRT Any anatomic body region and no peak specific absorption rate (SAR) limit	Device evaluation pre- and post-MR scan; troponin and myoglobin levels pre- and 6–12 hours post-MR scan	Troponin levels unchanged post-MR scan No significant change in atrial or ventricular pacing thresholds noted Median SAR 2.4 W/kg	MR scan performed safely and no change in cardiac biomarkers	Wilcoxon rank sum test	Single center, small cohort Excluded pacing-dependent patients No long-term follow-up
Mollerus et al[20] 2010	Single center, prospective cohort N = 103 patients, with 127 MR scans	Not pacing-dependent PM, ICD, or CRT, implanted at least 6 weeks prior to scan No restriction on SAR	Device evaluation pre- and post-MR scan and followed for at least 3 months	Median peak SAR measurements of 2.5 W/kg Pre- and post-scan pacing thresholds unchanged Sensed RV amplitudes ($P < .00001$) and lead impedances (RA, RV) ($P < .0001$) decreased	One patient with device reset One ICD had arrhythmia log erased during scan No significant study-related events seen at 3-month follow-up	Paired Wilcoxon rank sum test for continuous variables, Kruskal-Wallis test for categorical values	Single center; excluded pacing-dependent

Friedman et al[21] 2013	Prospectively collected single-center cohort with retrospective analysis of patients with or without recently implanted leads N = 171 patients with 219 scans, of which 8 had recently implanted leads	Not pacing-dependent	Device evaluation pre- and post-MR scan and with comparison of patients with recently implanted (<42 days) leads	8 patients with recently implanted leads (7–36 days) No complications in either the early or late group and no difference in parameters One patient imaged 79 days after implant had frequent PVCs during scan with no action needed Overall, statistically but not clinically significant changes seen after MR scan in R-wave voltage, ventricular threshold, and atrial impedance	MR imaging feasible in patients with recently implanted PMs No clinically significant changes in function or on follow-up (average 104 days post-MRI) Regression analysis of all 171 patients did not predict any change in pacing variables according to implant duration at time of scan	Regression analyses with generalized estimating equation models to compare pre- and post-MR scans, and to account for multiple scans in the same patient	Small number of patients in the recently implanted group
Higgins et al[22] 2015	Prospective, single-center cohort N = 198 patients with 256 MR scans	Not pacing-dependent	Incidence of POR in relation to device characteristics and patient characteristics	PORs occurred in 9 MRI scans in 8 patients and more frequently in Medtronic devices ($P = .005$) and devices released before 2002 POR caused decrease in heart rate (n = 4) and transient anomalous battery life indication in 1	POR infrequent and occurred in older generators (released prior to 2002)	Pearson chi-squared for categorical variables, Wilcoxon rank sum or *t* test for continuous variables	Retrospective analysis of a small number of events and majority of patients in the entire database had Medtronic devices Pacing-dependent patients excluded, for which clinical effects of a POR could have been more important

Naehle et al[23] 2009	Prospective, single-center cohort N = 18 patients, with 18 MR scans	ICD-only Not pacing-dependent At least 3 months from implantation	Safety Lead parameters pre-, post- and at 3 months after MR scan Serum troponin 1 hour before and 12 hours after MR scan	No significant changes in pacing threshold, impedance seen No significant change in troponin observed	Battery voltage decreased from pre- to post-MR (P = .042) In 2 scans oversensing as VF occurred but no attempt at therapy delivery was made	Troponin levels compared with Student t test, other comparisons with a Wilcoxon signed rank test	Small case series
Higgins et al[24] 2014	Retrospective, single-center cohort N = 19 patients with abandoned leads (no generator) with N = 35 MR scans	Abandoned leads (no CIED generator) Not pacing-dependent	Safety Lead parameters	Mean of 1.63 abandoned leads per patient. 3 ICD leads, with 2 being dual coil 9 patients had long-term follow-up with no negative sequelae	No adverse events within 7 days of scan When generator reimplanted (12 of 19 patients) there were no lead malfunctions or clinically significant changes in pacing threshold, but one patient had ventricular lead threshold that rose from 1.9 V to 2.6 V at 0.5 ms	Not provided	Small single center, retrospective Unknown whether presence of a generator with functional leads could have affected results No cardiac biomarkers analyzed
Strom et al[42] 2017	Prospective, single-center cohort N = 189 scans on 123 patients	Any PM or ICD; abandoned leads a relative contraindication	Safety Clinical Utility	No deaths or system revision acutely or at 6 months 1 power on reset event	98.4% of scans were interpretable 75% of scans met pre-specified criteria for clinical utility	Event rates evaluated with binomial distribution Linear mixed-effect models to evaluate system parameter changes Kappa for evaluation of two-	Strom et al 2017

						reader adjudication of utility	

CIED =cardiac implantable electronic device; ICD =implantable cardioverter defibrillator; VF =ventricular fibrillation; POR =power-on reset; CRT=cardiac resynchronization therapy; SAR =specific absorption rate; DFT 5 defibrillation threshold test.

*e.g., mortality or morbidity %

†e.g., P value, hazard ratio, odds ratio, confidence intervals