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Wideband MDE and DL-based image reconstruction in patients with MR-Conditional cardiac implants

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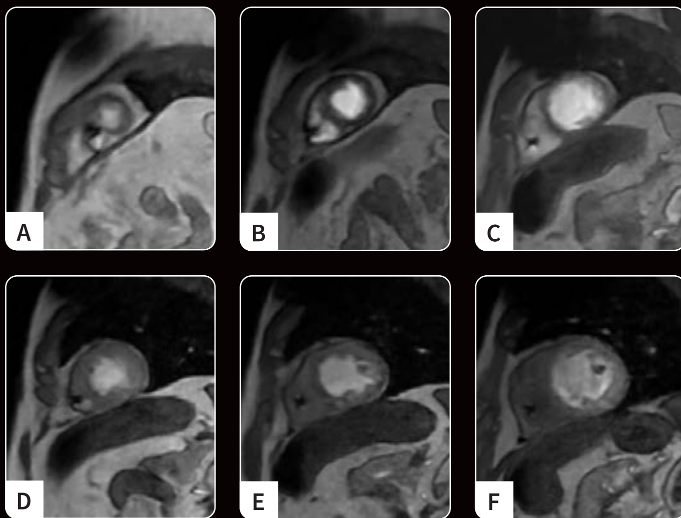
Cardiac MR (CMR) is a clinically valuable tool to identify myocardium delayed enhancement (MDE) patterns, aiding in the diagnosis and treatment of myocardial diseases such as ischemic and nonischemic cardiomyopathies, among others. Patients with cardiomyopathies often have cardiac implantable electronic devices (CIEDs), which pose a technical challenge to standard MDE imaging sequences.

UChicago Medicine is a high-volume CMR center, performing over 1,000 studies annually. As a referral site within our regional network, we routinely conduct comprehensive cardiac examinations, including quantitative stress perfusion. Additionally, we see a significant number of patients with CIEDs in whom MDE with integrated wideband makes a remarkable difference.

Many of these patients face challenges such as difficulty with breath-holding and arrhythmias. Therefore, having the right tools to conduct cardiac examinations in a population with diverse conditions is crucial. Using conventional CMR techniques often results in non-diagnostic studies for these

SIGNA™ Artist 1.5T				
	SPGR perfusion	T1 map - MOLLI	Wideband 2D MDE	T2 map
TR (ms):	3.1	3.1	5.9	
TE (ms):	1.5	1.5	2.8	4 echos
FOV (cm):	38 x 29	36 x 32	36 x 36	36 x 32
Slice thickness (mm):	8	8	8	8
Frequency:	192	160	220	160
Phase:	148	132	152	128
NEX:	0.75	1	1	
Scan time (sec.):	Rest: 76-115; stress: 65-80	11/slice	~10/slice	17/slice
Options:	AIR™ Recon DL, Acc 2, flip angle 15°, motion correction	AIR Recon DL, Acc 2, flip angle 5°, motion correction	AIR Recon DL, Acc 2, flip angle 20°	AIR Recon DL, Acc 2.5, ETL 24



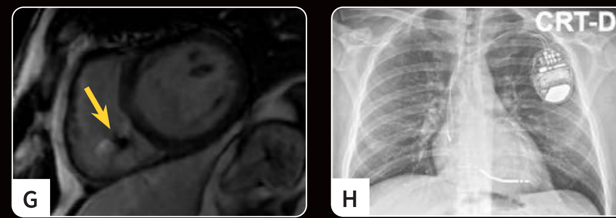


Figure 1. Case 1, a 51-year-old male with heart failure with reduced ejection fraction and an ICD implant (ICD lead, yellow arrow) admitted for decompensated heart failure. The perfusion study was conducted (A-C) at rest and (D-F) under stress, followed by (G) a MDE sequence. (H) Chest X-ray depicts CIED placement. Despite the low positioning of the ICD implant, perfusion assessment was unaffected due to the wide 5 kHz bandwidth of the saturation recovery pulse on the SPGR perfusion sequence. The Wideband MDE, with a 4 kHz bandwidth, also enabled a clear analysis of the myocardium, overcoming the challenges of an inconclusive echocardiogram where significant contrast swirling obscured apex visualization. MR effectively ruled out both perfusion abnormalities and thrombus, allowing the patient to safely continue anticoagulation therapy with continued monitoring.

patients. Moreover, the need to repeat multiple sequences or the full exam can be burdensome for patients and negatively impact scheduling productivity.

In a cohort of patients with severe arrhythmias, it is not uncommon for nearly 20% of the exams to be deemed non-diagnostic. In cases where we are evaluating for a cardiac mass or thrombus, imaging artifacts caused by a CIED can also result in a non-diagnostic study.

In our center, we use Cine for functional assessment and MDE for viability. As part of GE HealthCare's cardiac portfolio, Wideband is integrated into all MDE sequences, including 2D MDE (segmented and SnapShot), 2D PSMDE (segmented and SnapShot) and 3D MDE with or without FatSat. This is a feature that runs in the background and does not need to be turned on by the user.

Wideband, which has been available on MDE sequences for several years on GE HealthCare MR systems, has been expanded to include T1 mapping and perfusion. Additionally, motion correction has been incorporated into the T1 mapping and perfusion sequences.

We are now using Wideband MDE in this high-risk population with excellent image quality results. Recent clinical guidance recommends the use of Wideband techniques for T1 mapping and perfusion CMR.[1]

A Wideband MDE adiabatic pulse is applied to improve tissue nulling, making it more robust against inversion inaccuracies caused by MR-Conditional CIEDs. Our initial evaluation was that Wideband MDE was diagnostic at baseline. The addition of AIR Recon DL to the Wideband MDE sequence, as well as to perfusion, T1 mapping and T2 mapping, provides significant improvement in image quality, particularly in patients with implants where imaging is often sub-optimal (Figures 2 and 4). These noticeable improvements in image quality also increase our diagnostic confidence.

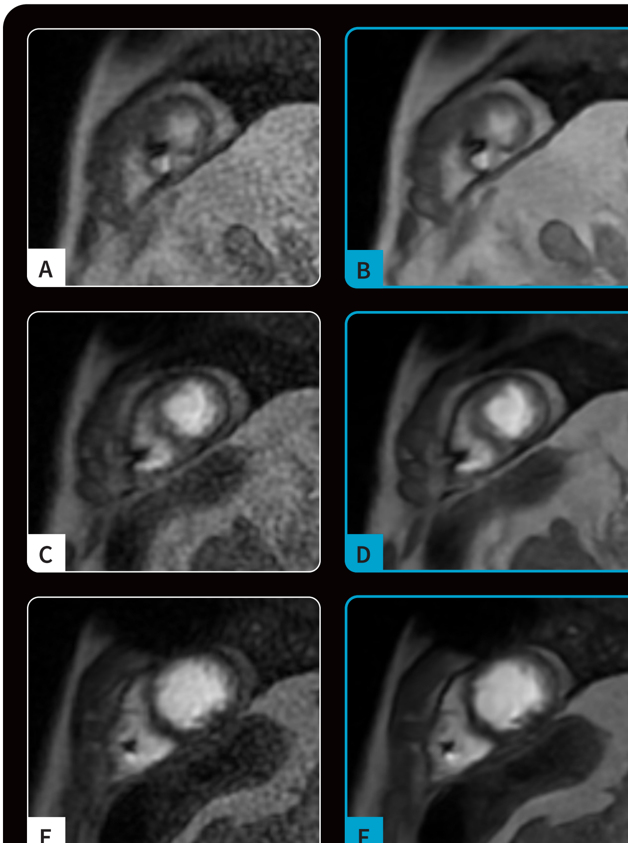


Figure 2. Case 1, same patient as Figure 1. (A, C, E) Comparison of perfusion images with conventional reconstruction and (B, D, F) with AIR Recon DL. Images reconstructed with AIR Recon DL show improved SNR and enhanced sharpness, providing easier and more comfortable myocardial analysis. This improvement allowed for confident exclusion of myocardial perfusion abnormalities.

During CMR stress and rest perfusion imaging, a nurse is present to administer the vasodilator and reversal agents, in addition to a technologist and cardiologist. When the patient has a defibrillator, we also have an electrophysiology nurse in the room to monitor the device. This workflow and personnel requirements also extend the time the patient is in the MR room. Having the ability

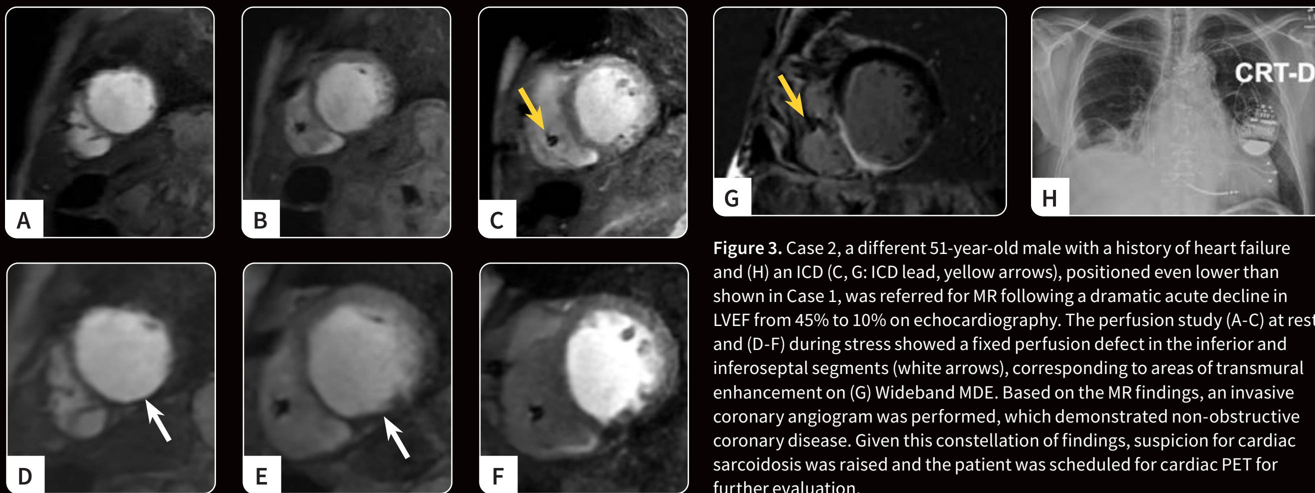


Figure 3. Case 2, a different 51-year-old male with a history of heart failure and (H) an ICD (C, G: ICD lead, yellow arrows), positioned even lower than shown in Case 1, was referred for MR following a dramatic acute decline in LVEF from 45% to 10% on echocardiography. The perfusion study (A-C) at rest and (D-F) during stress showed a fixed perfusion defect in the inferior and inferoseptal segments (white arrows), corresponding to areas of transmural enhancement on (G) Wideband MDE. Based on the MR findings, an invasive coronary angiogram was performed, which demonstrated non-obstructive coronary disease. Given this constellation of findings, suspicion for cardiac sarcoidosis was raised and the patient was scheduled for cardiac PET for further evaluation.

to abbreviate the CMR examination time is important from a standpoint of other patient access to the scanner, as well as department throughput and efficiency.

GE HealthCare MR software includes a Low SAR Mode, allowing the user to specify even lower limits for SAR or B1+RMS. Most MR-Conditional CIEDs specify 2.0 W/kg for SAR at 1.5T; however, those that are MR-Conditional at 3.0T can have lower limits. For example, a commonly used MR-Conditional pacemaker specifies a maximum B1+RMS=2.8µT for thoracic imaging, which can be easily set in Low SAR Mode. The availability of 3.0T imaging combined with Low SAR Mode is expected to be important if the scan is clinically indicated for 3.0T (e.g., PET/MR) or for institutions without access to a 1.5T system.

Improvements in CMR imaging may also allow for better assessment and quantification of coronary perfusion. At UChicago Medicine, we are participating in a multicenter trial to validate these techniques and study different patient populations to better understand coronary microvascular flow. Post-transplant patients and women are two subgroups where microvascular disease is more prevalent.

Adding rapid imaging techniques such as Sonic DL™ can achieve significant scan time reductions, reportedly up to 83%. Sonic DL also enables single-heartbeat and free-breathing acquisitions to address imaging of patients who cannot hold or have limited breath-holding ability. Additionally, faster scan times may lead to less concern among the clinical staff regarding these patients with CIEDs undergoing CMR, where we shut off their defibrillator therapies and have requirements for additional staff (e.g., nurses, doctors) in the MR room.

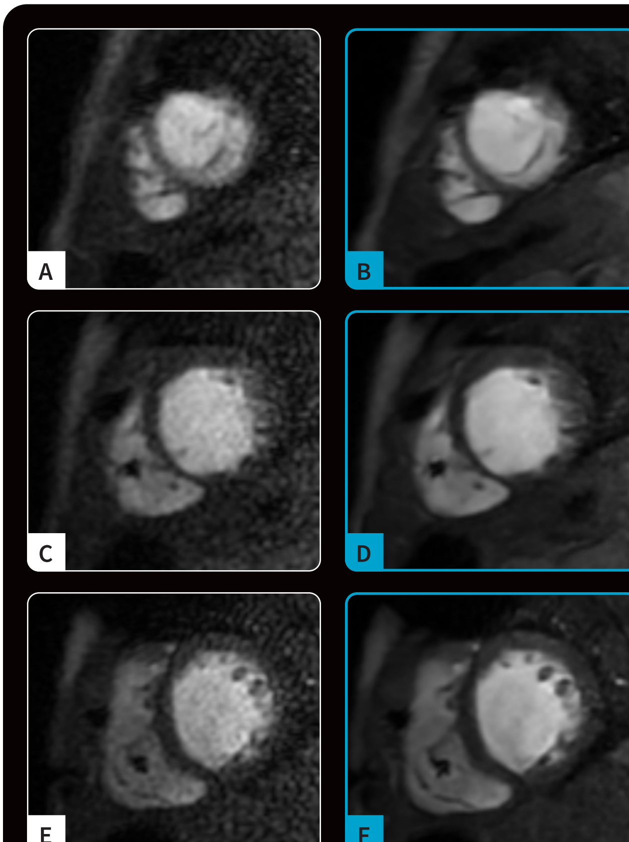


Figure 4. Case 2, same patient as Figure 3. Comparison of perfusion images with (A, C, E) conventional reconstruction and (B, D, F) with AIR Recon DL. Images reconstructed with AIR Recon DL show improved SNR and enhanced sharpness, which enabled the diagnosis of hypoperfusion in the inferior and inferoseptal segments. This diagnosis would have been challenging to achieve on images without AIR Recon DL due to the high noise levels surrounding and within the myocardium.

Patient cases

Case 1

A 51-year-old male with a past medical history of heart failure with reduced ejection fraction and CIED implantation who was admitted with decompensated heart failure. An echocardiogram was performed and showed acute decline in his left ventricular ejection fraction (LVEF) from 45% to 10%. He was subsequently referred for stress perfusion cardiac MR to assess for potential etiologies of acute LV function decline. Coronary angiogram was initially deferred, given abnormal renal function. In addition to severe LV dysfunction, CMR showed a fixed perfusion defect in the inferior and inferoseptal segments corresponding with areas of transmural late gadolinium enhancement. Given these findings, invasive coronary angiogram was performed and showed nonobstructive coronary disease. The constellation of these findings raised suspicion for cardiac sarcoidosis, and he was referred to cardiac PET for further evaluation.

Case 2

A different 51-year-old male than discussed previously with a history of heart failure with reduced ejection fraction secondary to non-ischemic cardiomyopathy, status post cardiac resynchronization therapy with defibrillator (CRT-D) and LV thrombus was referred for outpatient evaluation of chest pain and assessment of the LV thrombus. The patient remained on anticoagulation due to his history of LV thrombus.

Echocardiographic imaging was suboptimal for visualization of the apex, given significant contrast swirling. However, stress CMR imaging demonstrated normal perfusion and no evidence of LV thrombus. Consequently, anticoagulation was discontinued, with ongoing surveillance recommended.

Discussion

As shown in these two cases, CMR can impact diagnosis and lead to appropriate changes in patient management. The addition of AIR Recon DL and utilization of the Wideband technique on MDE and T1 mapping have been practice-changing in a short period of time. Referrals for MR-based ischemic evaluations in MR-Conditional cardiac implanted patients have increased. Previously, we've had anywhere from two to five referrals every other week; however, as our referral network becomes more familiar and comfortable with stress perfusion and Wideband MDE studies, we are receiving an increase in requests. In just one recent day, we received three referrals for this type of study.

Diagnosis and clinical management have also been favorably impacted. We can now diagnose ischemia and various scar patterns in patients in whom we previously would not have obtained a successful, diagnostic-quality CMR examination.

In some patients, our success with CMR has the added effect of reducing the number of imaging studies these patients must undergo. We can achieve ischemic evaluation and tissue characterization in one CMR study without the patient undergoing multi-modality imaging or an invasive procedure for assessment. This capability also positively impacts the patient and health system economically by avoiding multiple diagnostic tests or invasive procedures that require sedation, contrast, radiation and a potential hospital stay.

Reference

1. Kim D, Collins JD, White JA, et al. SCMR expert consensus statement for cardiovascular magnetic resonance of patients with a cardiac implantable electronic device. J Cardiovasc Magn Reson. 2024 Summer;26(1):100995.