

Life-speed imaging with Sonic DL Cine opens up cardiac MR access to those who need it most

Every so often, a new technology emerges that challenges our assumptions and beliefs. In the world of cardiac MR (CMR), conventional imaging techniques have limited access to many patients who could benefit from this comprehensive, non-invasive examination. Arrhythmias, inability to breath-hold and claustrophobia are among the conditions that often precluded the use of CMR in some of the sickest cardiac patients. After all, it is not easy to capture high-quality images of a moving, beating heart. Until now.

Life-speed imaging with Sonic DL™ Cine changes this paradigm by opening up access to those who need it the most. Using deep

learning, scan times are cut from minutes to seconds with up to 12-times acceleration speeds, enabling the capture of high-quality images in just one heartbeat or with free-breathing. Acceleration with Sonic DL delivers speed to match the human body, enabling image acquisitions that were previously not possible.

On the following pages, a diverse group of clinicians demonstrate the clinical capabilities of Sonic DL Cine and how it delivers accurate CMR imaging data and increases access to more patients, giving clinicians actionable insights to advance patient care.



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One-day implementation expands CMR capabilities from the tiniest to the most frail patients

At Istanbul University, Memduh Dursun, MD, Professor of Radiology, has seen firsthand the challenges of performing CMR in patients. The radiology department conducts approximately 300 CMR exams annually, with an average exam time of 1 hour. Unfortunately, 10-15% of these exams were unsuccessful due to the patients' inability to hold their breath, arrhythmias or inadequate image quality. Scans were often repeated, causing increased patient discomfort.

"It was clear we needed a solution that could adapt to these challenging cases, to push the boundaries of what is possible in cardiac imaging," says Professor Dursun. "Our primary goal with Sonic DL Cine was to transform the way we approach cardiac MR by reducing scan times, enhancing image quality and making the experience more comfortable for our patients."

The department also aimed to expand its CMR capabilities to include even the most challenging patients – those with

arrhythmias or breathing difficulties who often could not complete the examinations or had non-diagnostic results – all while maintaining diagnostic accuracy.

In just one day, Sonic DL Cine was implemented, tested on volunteers and used to scan an adult patient with aortic regurgitation and a newborn.

“The one-day implementation of Sonic DL Cine was a remarkable feat, made possible by the close collaboration between our department and the technical expertise of the GE HealthCare team,” adds Professor Dursun. “It was a true partnership that allowed us to integrate this technology seamlessly into our existing workflow.”

An invaluable tool to manage cardiac patients

To initially test the solution, Istanbul University Department of Radiology compared traditional breath-hold and free-breathing methods with Sonic DL Cine capabilities. The comparison was pivotal in helping Professor Dursun and colleagues understand how to implement technology for each clinical scenario and integrate it into their clinical practice.

“What impressed us was how significantly Sonic DL Cine reduced the need for breath-holding, making scans not only more efficient but also much more comfortable for patients,” Professor Dursun says.

After the initial testing and sequence optimization, the department scanned its first patient, an adult cooperative patient with aortic regurgitation (Figures 1-3). Professor Dursun observed a significant reduction in scan time in multi-slice

multiphase acquisitions, up to 70% less time in the short axis cine acquisition than traditional methods. He also saw a notable improvement in image quality. For example, he explains that previously the off-resonance artifacts from the jet flow presence would impact the image quality across the slices.

“Sonic DL Cine allowed for clearer visualization of the valve’s anatomy, which is crucial for assessing the severity of aortic regurgitation,” he explains. “We can assess accurately the severity of the condition, which is essential for guiding treatment decisions.”

The improved diagnostic accuracy directly impacted patient care by enabling more precise treatment planning. Professor Dursun could confidently decide whether surgical intervention was necessary and what type of intervention would be most beneficial.

“This level of precision is invaluable in managing complex cardiac conditions. Sonic DL Cine is great for enhancing our diagnostic capabilities.”

Prof. Memduh Dursun

That same day, the department received a request to examine a neonatal patient with a suspected cardiac mass (Figures 4-5). The team achieved remarkable reductions in scan time, faster temporal resolution and improvements in image quality, which are critical for neonates who cannot hold their breath and require minimal sedation. Professor Dursun adds that when

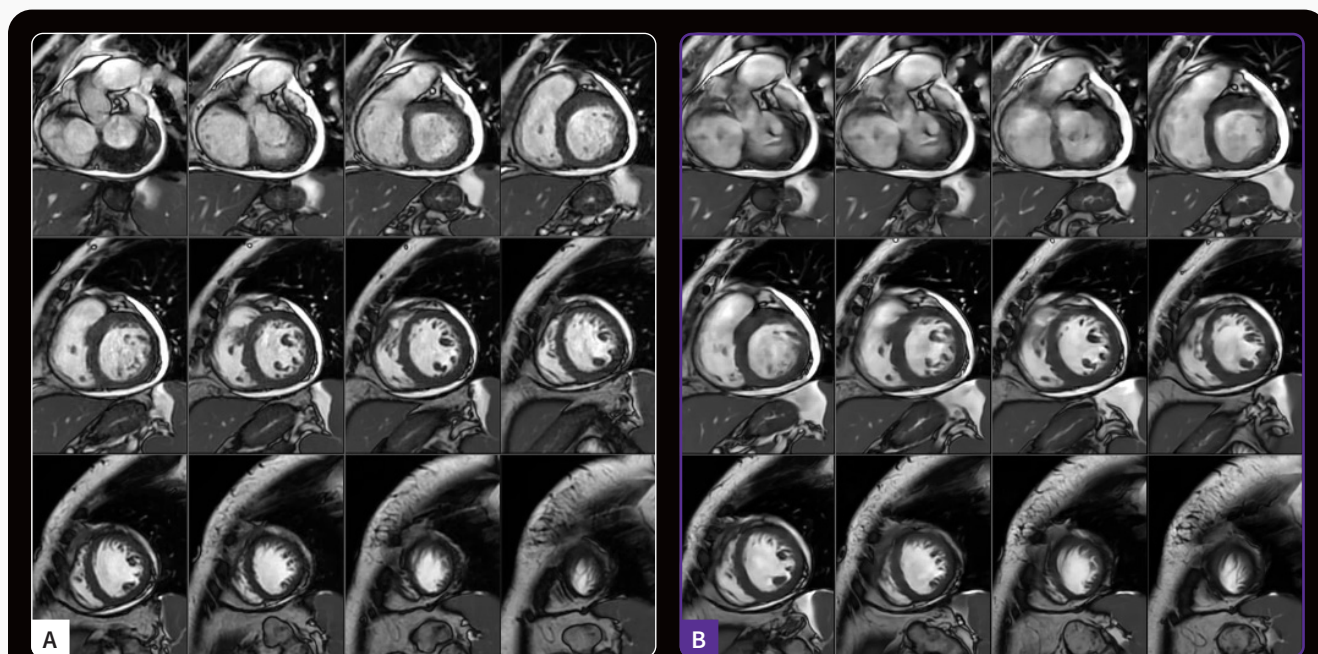


Figure 1. Cooperative adult patient with aortic regurgitation. (A) Cine FIESTA without Sonic DL Cine, 1.9 x 1.9 x 8 mm, 15 slices, 1:16 min. scan time, 3:40 min. total acquisition time with eight breath-holds. (B) Sonic DL Cine, 8x acceleration factor, 3 R-R, 1.4 x 1.4 x 8 mm, 46 sec. scan time, 1:06 min. total acquisition time with three breath-holds.

scanning neonates, it's essential to consider their fragile condition and the need for minimal sedation.

"The enhanced image quality increased our diagnostic confidence in assessing pericardial effusion with clear decision of discarding any cardiac mass. This allowed for more accurate diagnosis and timely intervention, which is critical in neonates," Professor Dursun says. "Thanks to Sonic DL Cine, it enabled us to make informed decisions about surgical interventions and post-operative care. Sonic DL's ability to reduce scan times makes it an ideal solution for this vulnerable patient group, and this neonatal case highlights the versatility and potential of Sonic DL Cine in challenging scenarios."

AIR™ Recon DL and motion correction solutions were already integral to the institution's daily CMR routine for many applications, such as MDE, black-blood, mapping and time-course images.

"These technologies work in harmony to further enhance image quality and minimize motion artifacts, especially in our most challenging cases. It's been a game-changer for us. Together, Sonic DL Cine and AIR Recon DL enable a comprehensive cardiac MR exam that answers clinical questions and guides patient management effectively. It's a powerful combination that has elevated our practice to new heights."

Prof. Memduh Dursun

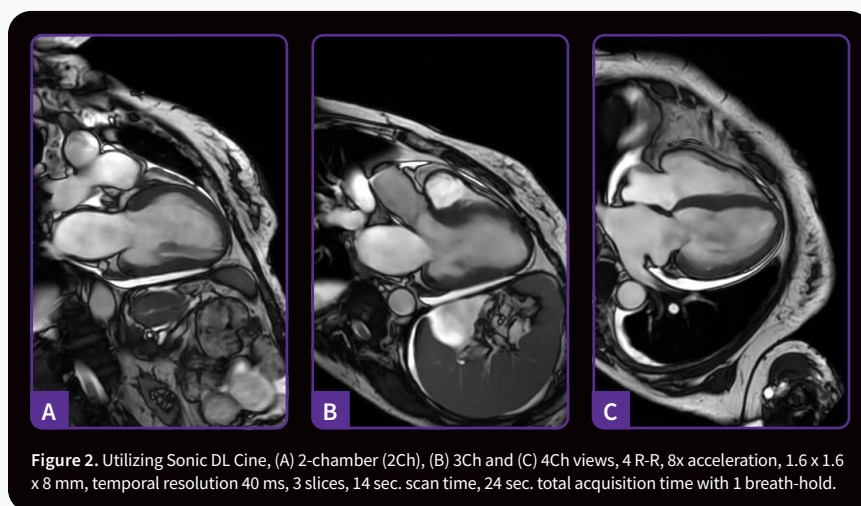


Figure 2. Utilizing Sonic DL Cine, (A) 2-chamber (2Ch), (B) 3Ch and (C) 4Ch views, 4 R-R, 8x acceleration, 1.6 x 1.6 x 8 mm, temporal resolution 40 ms, 3 slices, 14 sec. scan time, 24 sec. total acquisition time with 1 breath-hold.

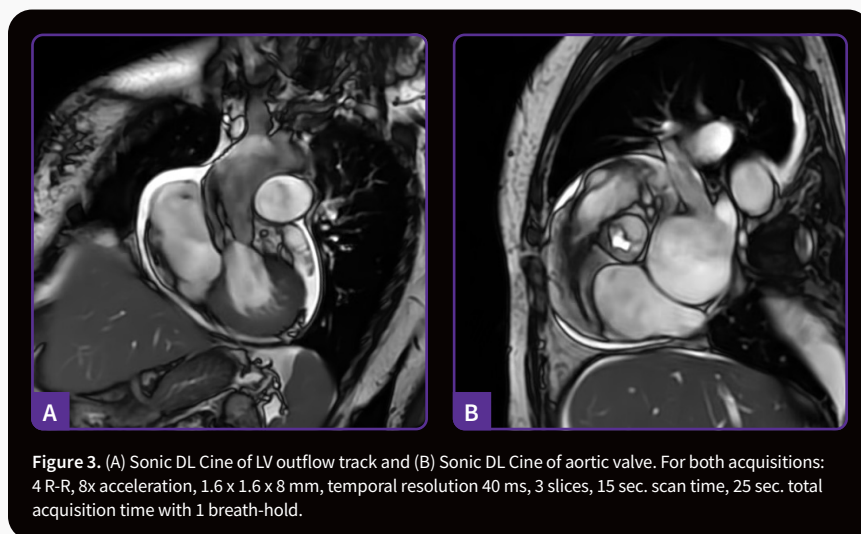


Figure 3. (A) Sonic DL Cine of LV outflow track and (B) Sonic DL Cine of aortic valve. For both acquisitions: 4 R-R, 8x acceleration, 1.6 x 1.6 x 8 mm, temporal resolution 40 ms, 3 slices, 15 sec. scan time, 25 sec. total acquisition time with 1 breath-hold.

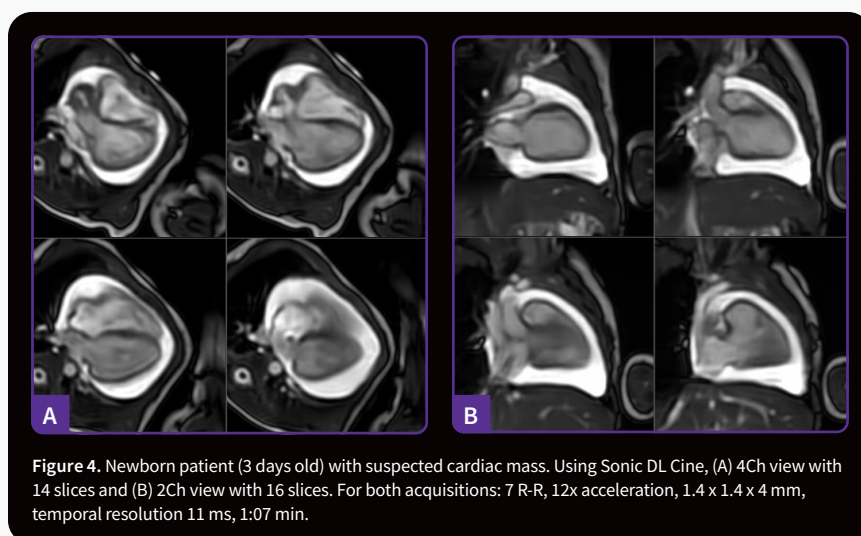


Figure 4. Newborn patient (3 days old) with suspected cardiac mass. Using Sonic DL Cine, (A) 4Ch view with 14 slices and (B) 2Ch view with 16 slices. For both acquisitions: 7 R-R, 12x acceleration, 1.4 x 1.4 x 4 mm, temporal resolution 11 ms, 1:07 min.

The latest MR software from GE HealthCare has transformed Istanbul University's ability to image difficult

patients, improving both diagnostic accuracy and patient comfort. Professor Dursun also cites the collaboration with

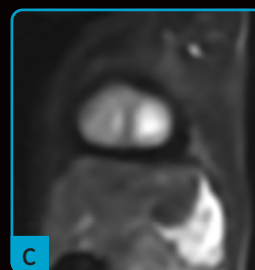
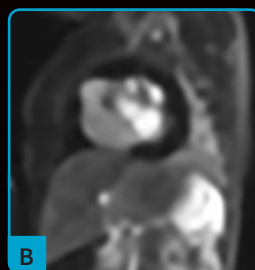
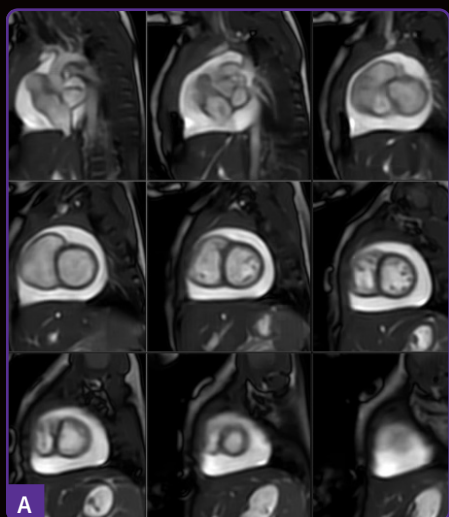


Figure 5. Same patient as Figure 4. Newborn patient (3 days old) with suspected cardiac mass. (A) Sonic DL Cine short axis, 8 R-R, 12x acceleration, 1.4 x 1.4 x 4 mm, temporal resolution 16 ms, 12 slices, 1:04 min. (B-D) Cardiac perfusion was performed in free-breathing with Time Course AIR Recon DL and motion correction (MoCo) in (B) short axis (C) 4Ch views, 3.9 x 3.9 x 7 mm, temporal resolution 10 ms, 2 slices, 45 sec.

clinical experts from GE HealthCare as crucial for a seamless implementation process. He adds, “I would strongly recommend considering the integration of Sonic DL Cine alongside AIR Recon DL and motion correction features.

“Sonic DL Cine has been instrumental in successfully imaging challenging patients, including those with arrhythmias or breathing difficulties,” Professor Dursun continues. “This has significantly expanded our patient pool and improved

overall diagnostic success rates. It’s fulfilling to see how this technology has opened doors for patients who previously faced barriers to receiving accurate diagnoses.” **S**



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Changing the paradigm in pediatric diagnostic and interventional CMR

In pediatric hospitals, a faster CMR examination impacts patients beyond obtaining the answer to a clinical question, but still must be thorough and complete. Pediatric patients generally need anesthesia to complete a CMR exam, but a faster CMR examination can reduce the amount of anesthesia needed, or in some cases, can eliminate the need for sedation altogether. It enables the acquisition of important structural and functional data that can be challenging in complicated pediatric cardiac cases, providing information to change the course of patient management, including timing and planning of potentially life-saving interventions or surgery.

At Le Bonheur Children’s Hospital, a Magnet-designated facility ranked one of the best children’s hospitals in the US for 14 consecutive years by *U.S. News & World Report*, CMR is integral to

the care clinicians provide. The hospital also routinely performs interventional catheterization cases and recently has developed its interventional CMR program in children with congenital heart disease, opening the door to guided hemodynamic studies and combined electrophysiology procedures.

“Throughput is generally related to the feasibility of completing examinations and turning over the room. In pediatrics this can be challenging and is less related to increasing scheduled slots and is more multifactorial with multiple stakeholders to coordinate,” says Anthony Merlocco, MD, MSt (Oxon), FSCMR, Director of Cardiac MRI at Le Bonheur. “The younger patients are, the more they are affected by claustrophobia or just simply unable to complete the scan, and it can be variable how long a successful scan can take.”

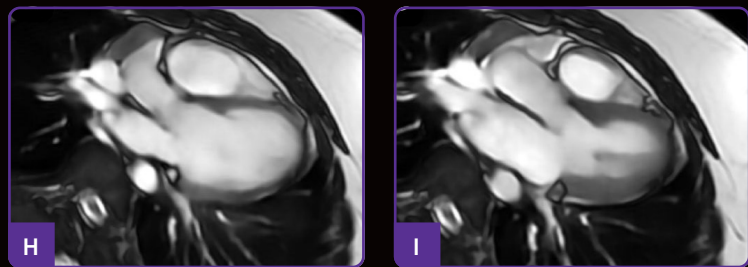
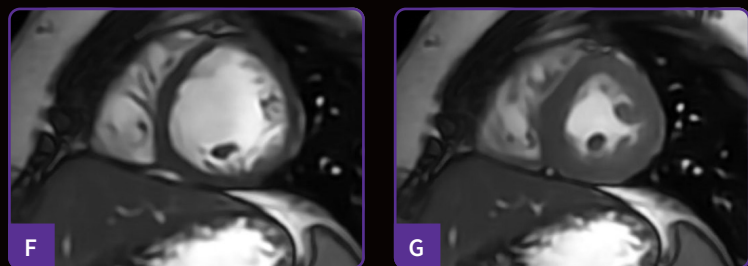
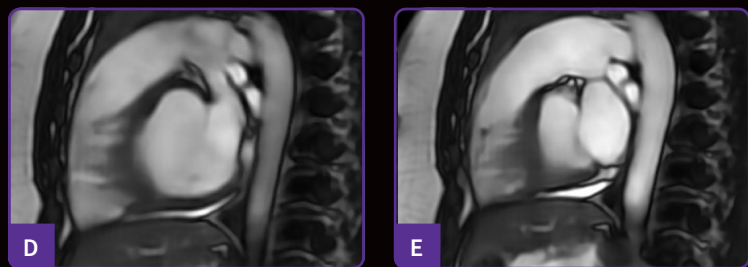
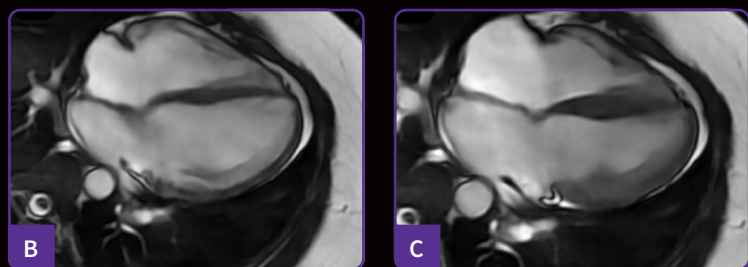
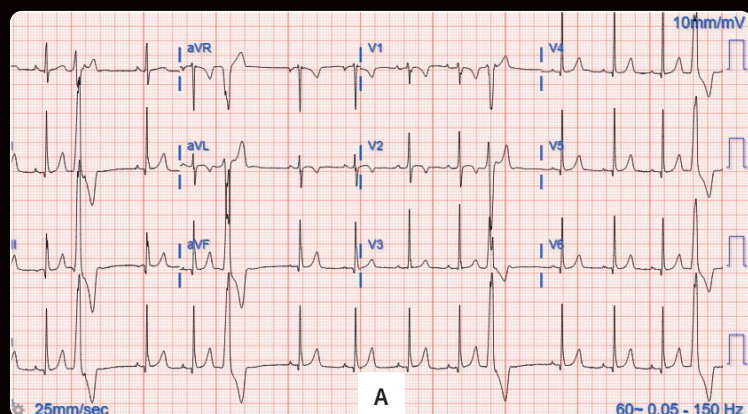


Figure 6. A 9-year-old male with an irregular heartbeat during evaluation for shortness of breath. (A) Twelve lead electrocardiogram with normal sinus rhythm and frequent premature ventricular contractions of right ventricular outflow tract origin. Sonic DL Cine was utilized for the examination. (B, C) 4Ch, 1 R-R cine and (D, E) right ventricular outflow tract views in (B,D) end-diastole and (C,E) end-systole. There is normal bi-ventricular systolic function with no regional wall motion abnormalities. (F, G) Mid short axis, 1 R-R cine and (H, I) 3Ch views in (F, H) end-diastole and (G, I) end-systole. There is normal bi-ventricular systolic function with no regional wall motion abnormalities.

Age is the first factor considered when deciding whether the CMR examination can be performed without sedation or anesthesia. While avoiding anesthesia has the clear advantage of reducing associated risks, there are logistical considerations as well. These include scheduling and the need for a longer scanning slot, availability of a recovery bed, as many CMR examinations are performed on outpatients, anesthesiologist availability for an unplanned sedation and, in some cases, avoiding another trip for the patient and their parent/family to the hospital for the sedated CMR after attempting to conduct the examination without it.

The impact of Sonic DL Cine in pediatric CMR

Le Bonheur recently installed a SIGNA™ Artist 1.5T MR with MR30.1 software, which includes Sonic DL Cine. Soon after, a 9-year-old patient with significant claustrophobia and an existing condition of ectopic heart beats required evaluation. Despite medication for the extra heart beats, they remained frequent, which often adds challenges to the CMR, given limitations in gating and arrhythmia rejection. The electrocardiogram showed frequent premature ventricular contractions (PVCs) and a Holter monitor showed 25% PVC burden; however, a CMR was still thought to be worthwhile to attempt (Figure 6A).

“The frequent ectopy on his monitor presented an ongoing concern, and indeed on one strip he demonstrated a short run of ventricular tachycardia, a dangerous heart rhythm, so more information was needed,” says Dr. Merlocco.

The plan was to perform a free-breathing CMR. Even with free-breathing however, many patients, especially those with claustrophobia, will keep stopping the scan to ask questions, come out of the bore or hear one’s voice. With this in mind, Dr. Merlocco and the Le Bonheur CMR team decided to try Sonic DL Cine in this patient’s case. Having a 1 R-R acquisition would substantially reduce the cine scan time and, therefore, reduce the potential for scan stoppages; but, any new sequence also requires significant scan optimizations,

particularly for pediatric patients. However, a GE HealthCare advanced clinical specialist was still on-site post-installation and rapidly modified the protocol to a 1 R-R Sonic DL Cine acquisition during the exam. They were able to complete the standard 2-chamber, 3-chamber, 4-chamber stack, short axis stack, right ventricular (RV) outflow tract (RVOT), pulmonary valve, and aortic valve cine acquisitions with standard field of view (320 mm), slice thickness (8 mm), repetition time (3 msec), respiratory gating, and flip angle (55°), with an imaging time of only 0.954 second per slice, accomplishing a temporal resolution of 30 phases/sec. This allowed them time to complete the remaining parts of the protocol, including T1 map (short axis 3 slice), T2 map, rest perfusion and SS phase sensitive inversion recovery (Figure 6).

The entire imaging protocol took only 19 minutes.

“Adjustments to the Sonic DL Cine allowed us time to include all the other imaging we standardly perform,” says Dr. Merlocco. “Other options for managing the issues we faced, such as real-time imaging with free-breathing or trying to do a breath-hold and averaging, weren’t as optimal alternatives for this patient. The Sonic DL Cine sequence allowed for quick free-breathing assessment of ventricular function with detail to evaluate for regional wall motion abnormalities. It demonstrated its value in this case.”

This advancement allowed the collection of data at 1 slice/heartbeat (1 R-R), removing the need for sedation and providing exceptional image quality even during arrhythmia. The 1 R-R Sonic DL Cine provided the ability to detect mild RV chamber dilation (RV end-diastolic volume index of 105 ml/m²) and normal RV systolic function with ejection fraction (EF) of 52% with no regional wall motion abnormalities of the RV. There was top-normal left ventricular (LV) chamber size (LVEDVi

87 ml/m²) and normal LVEF of 56%. Based on the CMR, the patient did not meet criteria for arrhythmogenic cardiomyopathy, and a subsequent negative genetic cardiomyopathy panel further informed the clinician’s response to the arrhythmia. The hospital has tailored medical management to their condition and continues to monitor the patient.

“Standard arrhythmia rejection is helpful, but Sonic DL Cine can accomplish it much more efficiently by performing a full stack through the heart very quickly. With one heartbeat per slice, we know we are getting an accurate representation of what is going on with the ventricle, and if anything does need to be repeated due to arrhythmia, we know immediately and can accomplish this quickly.”

Dr. Anthony Merlocco

“Sonic DL Cine opens up access to CMR to different patients,” says Jason Johnson, MD, MHS, Chief of Cardiology, Le Bonheur Children’s Hospital. “A clinician may not order the CMR test in a 9-year-old claustrophobic patient, but if we can complete the examination in less than 20 minutes, then most children can get through that relatively easily. For this patient, Sonic DL Cine saved them from having anesthesia and we got the answers we needed for patient management.”

The hospital can reserve using anesthesia in patients where there are no other options, such as very complicated cases. Sedation and anesthesia will likely always have a role in pediatric CMR, but now

younger patients are offered non-sedated CMRs, ensuring the sedated slots go only to those most in need. Patients who have difficulty with breath-holding, such as those with muscular dystrophy, can now undergo free-breathing CMR. More complicated congenital heart disease patients who typically have difficulty in the MR bore may have more successful examinations without anesthesia.

“A good percentage of our patients should be able to have a non-sedated study when they would not have before because of the Sonic DL Cine sequence,” Dr. Johnson adds.

Sonic DL Cine utilization in interventional CMR

Interventional CMR (iCMR) provides several benefits for pediatric patients. It enables detailed anatomical and functional assessments, is radiation-free and is applicable across a wide range of procedures, including for structural abnormalities and electrophysiology procedures.

At Le Bonheur, iCMR is being utilized more often as MR-Conditional catheters and devices become commercially available. Dr. Johnson can clearly visualize detailed cardiac structures quickly, utilizing Sonic DL Cine with the 1 R-R acquisition for the functional congenital CMR prior to the interventional procedure.

iCMR provides functional data as well – something that can’t be acquired in a cath lab.

“We can obtain very accurate volumetric and functional data, such as flow assessments to calculate how much blood flow goes into the lungs or body, and now we can directly measure pressures in the magnet, which we couldn’t do before iCMR,” says Dr. Johnson. “And we can limit the radiation exposure and get the most accurate information in one examination.” Dr. Johnson, with assistance of the Le Bonheur Interventional Cardiology



Figure 7. Dr. Johnson and the Le Bonheur Interventional Cardiology team perform iCMR on a patient with Fontan physiology.

team, recently performed iCMR on a patient with Fontan physiology. First, the patient underwent a full diagnostic CMR, which took approximately 35 minutes with Sonic DL cine 1 R-R sequences significantly shortening the functional portion. However, he discovered the patient had significant infarction of the myocardium that was previously undiagnosed. Because the clinical team was prepared to perform iCMR on this patient, Dr. Johnson was able to move the catheters through the Fontan circuit and into the branch pulmonary arteries to obtain accurate pressures of the Fontan circulation throughout that system. The entire iCMR exam was completed in 15-20 minutes for a full diagnostic and interventional CMR in approximately 1 hour. The patient was moved to the cath lab to finish the procedure – not all catheters and wires needed for the procedure are MR-Conditional. However, the patient's radiation exposure was substantially reduced compared to performing the full procedure in the cath lab. Much of the angiography was conducted in the MR suite, thereby avoiding exposing the patient to a lengthy fluoroscopic procedure.

"In these complex interventional cases, I use Sonic DL Cine with free-breathing to go as fast as possible during the diagnostic portion, and I can complete the functional test with detailed images quickly. It helps truncate our diagnostic CMR so the entire anesthesia for the patient is much shorter."

Dr. Jason Johnson

Making a difference in pediatric cardiac care

In a CMR examination, Sonic DL Cine makes a significant difference by shortening the cine acquisitions so that Le Bonheur's clinicians can obtain a full complement of CMR data. The hospital also uses AIR™ Recon DL to shorten scan times and increase SNR for all compatible sequences, such as LGE, MDE, perfusion, etc. Most importantly, the sequences are not just faster but also high quality.

"I'm impressed by the temporal resolution of Sonic DL Cine and the ability to capture the data in one heartbeat in a patient with a heart rate of 60 bpm," says Dr. Merlocco. "It is quality imaging data that is not blurry or lower resolution. It can be processed in our analysis software just like any other CMR data."

Adds Dr. Johnson, "It's robust, accurate and gives you information that you didn't think was possible to acquire in a difficult, complicated patient. I've learned to trust this deep-learning sequence in patients where I previously would not have even tried to acquire the data, such as the claustrophobic patient with an arrhythmia and difficulty breath-holding. I use it frequently – it's just a matter of how much acceleration I use."

Sonic DL Cine is now part of the standard protocol for all Le Bonheur's patients regardless of their condition – from cardiomyopathy to congenital to arrhythmias and more. Dr. Merlocco believes it is a technology that may help them move away from using sedation/anesthesia in younger patients.



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Shorter CMR examination times lead to a decrease in anesthesia duration and less intubation in pediatric patients

Since 1890, UPMC Children's Hospital of Pittsburgh has been at the forefront of advancing pediatric care as an early adopter and developer of new and improved therapies and a top educator of tomorrow's pediatricians and pediatric subspecialists.

According to Adam Christopher, MD, pediatric cardiologist and Director of Cardiac MRI and CT, the hospital performs more than 500 CMR exams each year, with about 20% performed under anesthesia due to behavioral or developmental limitations with holding still. Until recently, nearly all anesthetized patients were intubated and muscle relaxed to undergo mechanical breath-holds, which required long recovery periods using limited anesthesia and nursing resources.

"One-third of our CMR examinations have a study indication of repaired complex congenital heart disease such as tetralogy of Fallot or palliated single ventricle disease, which often have associated EKG abnormalities or metallic susceptibility artifacts related to implants that make cardiac gating a challenge," Dr. Christopher says. "An additional 5% of patients with structurally normal hearts are referred specifically due to frequent ectopy, making assessment of cardiac function using conventional segmented cine a challenge."

The hospital has a SIGNA™ HDx 1.5T MR system that was recently upgraded to MR30.1 and includes Sonic DL Cine. Dr. Christopher and colleagues, including Tarek Alsaied, MD, pediatric cardiologist,

performed a study to determine an increase in CMR image quality and rate patient accessibility and experience.

Benefits of free-breathing CMR

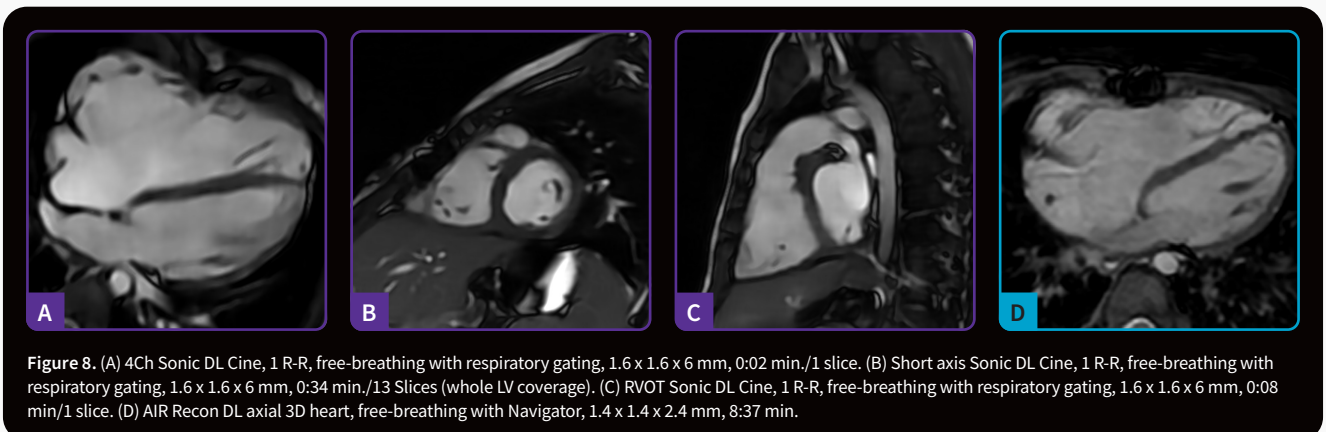
The clinicians conducted a few scans with the GE HealthCare clinical applications team to understand the new balance of scan time versus image resolution.

"Based on a study conducted at UPMC Children's Hospital, the use of Sonic DL Cine appears to represent a major step forward in imaging efficiency."

Dr. Adam Christopher

At UPMC Children's Hospital of Pittsburgh, Sonic DL has allowed any cardiac exam across a broad age and disease complexity range to be completed free-breathing, which has simplified their study planning and anesthesia protocols. Children can simply pick their movie to watch and only be disturbed again when the study is complete.

Free-breathing MR is particularly beneficial in patients with congenital heart disease who often have many developmental and genetic associations that make them less able to comply



with repeated breath-hold instructions. Their unconventional anatomies often require the acquisition of additional imaging planes, which increases the number of breath-holds and the overall examination time.

“Free-breathing examinations mean one less anesthetic induction,” says Dr. Alsaied. These congenital heart patients often undergo multiple surgeries, with the more complex patients often requiring lifelong care.

Now, Sonic DL Cine facilitates faster imaging and, therefore, more successful imaging by improving patient compliance. As important, Sonic DL Cine increases access to diagnostic CMR in patient populations that previously may have required anesthesia.

“We routinely perform our palliated single ventricle patient exams free-breathing and find that axial cine stacks are often additive to understanding complex post-surgical relationships,” says Dr. Christopher. “The 1 R-R acquisition typically adds only 30 seconds to the examination.”

Comparing CMR pre- and post-implementation of Sonic DL Cine

The cardiac imaging team at UPMC, including advanced cardiac imaging fellow Dr. Aditi Gupta, compared 150 pediatric CMR examinations and anesthesia durations before and after the implementation of Sonic DL Cine. With the implementation of Sonic DL Cine, the average study duration across all ages and

disease states fell by over 30%, from 43 +/- 13 minutes to 29 +/- 10 minutes.

“There was no compromise in imaging quality based on SNR measures. Some limited cases required 3 R-R cine acquisitions for more subtle valve assessments.”

Dr. Adam Christopher

Although there was no significant decrease in the utilization of anesthesia support, there was a decrease in anesthesia duration from 98 +/- 22 minutes to 67 +/- 11 minutes with the use of Sonic DL Cine. The approximate 30% decrease in anesthesia duration correlates to the study duration reduction.

Prior to Sonic DL Cine, 90% of anesthetized patients were intubated, while only 14% of patients were intubated after the application was implemented.

“We suspect intubation will continue to decrease as our anesthesia team gains further experience with these shorter CMR studies,” adds Dr. Christopher. He does note that the decrease in intubation may be attributed to other factors beyond the

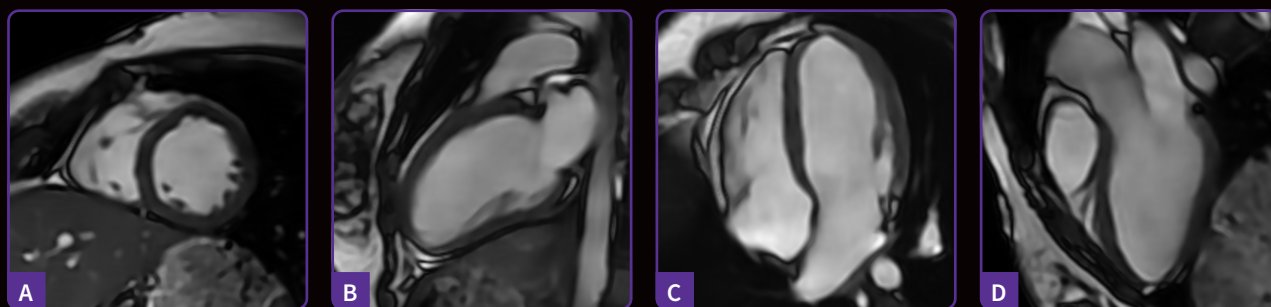


Figure 9. Short axis Sonic DL™ Cine, 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:40 min./12 slices (whole LV coverage). (B) 2Ch Sonic DL™ Cine, 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:07 min./1 slice. (C) 4Ch Sonic DL Cine, 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:06 min./1 slice. (D) 3Ch Sonic DL Cine, 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:08 min./1 slice.

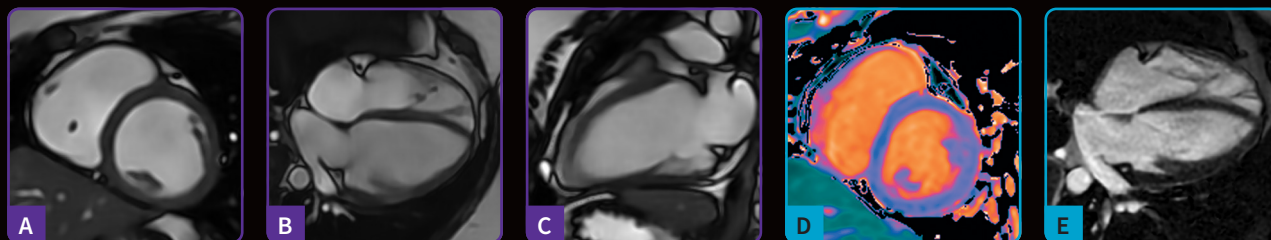


Figure 10. (A) Short axis Sonic DL Cine, 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:51 min./12 slices (whole LV coverage). (B) 4Ch Sonic DL Cine 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:10 min./1 slice. (C) 2Ch Sonic DL Cine, 1 R-R, free-breathing with respiratory gating, 2 x 2 x 6 mm, 0:07 min./1 slice. (D) AIR Recon DL short axis T1 mapping MOLLI with motion compensation, 2.4 x 3 x 8 mm, 0:27 min./3 slices. (E) AIR Recon DL 4Ch PSMDE, 1.7 x 1.7 x 6 mm, 0:09 min./1 slice.

imaging study, as anesthetized patients recover faster and easier given more limited interventions.

“We also find that our dark blood imaging with AIR Recon DL has dramatically improved SNR, which has furthered understanding of complex anatomies,” adds Dr. Alsaied. This is particularly apparent in the patients with significant MR-Conditional implants, where the higher SNR can assist with reading through artifacts.

The shorter CMR exam times, however, led to a new issue with the pediatric patients.

“Our awake, compliant patients complain that they don’t get to finish their movie by the time the exam is complete,” says Dr. Christopher.



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Increasing access to CMR in adult complex congenital heart disease patients

Adults with congenital heart disease often present with shortness of breath, palpitations, dyspnea and easy fatigability. These conditions, in addition to structural heart defects or atypical heart anatomy, can make cardiac imaging more difficult to perform and capture diagnostic results.

At the Institute for Cardiovascular Diseases Dedinje, Assistant Professor Goran Lončar, MD, PhD, FESC, oversees the CMR imaging of these complex patients. It is one of the busiest cardiac centers in the world, with more than 3,000 open heart surgeries, 2,500 percutaneous coronary interventions and 2,000 vascular or endovascular procedures each year.

Professor Lončar and colleagues have also participated in international studies, such as the STICH3C trial, which

assessed cardiac viability using CMR in patients with multi-vessel coronary artery disease with decreased left ventricular ejection fraction ($\leq 40\%$) who underwent either percutaneous

coronary intervention or coronary artery bypass graft surgery.¹

The Institute installed a SIGNA™ Artist 1.5T in November 2022 and in the first eight

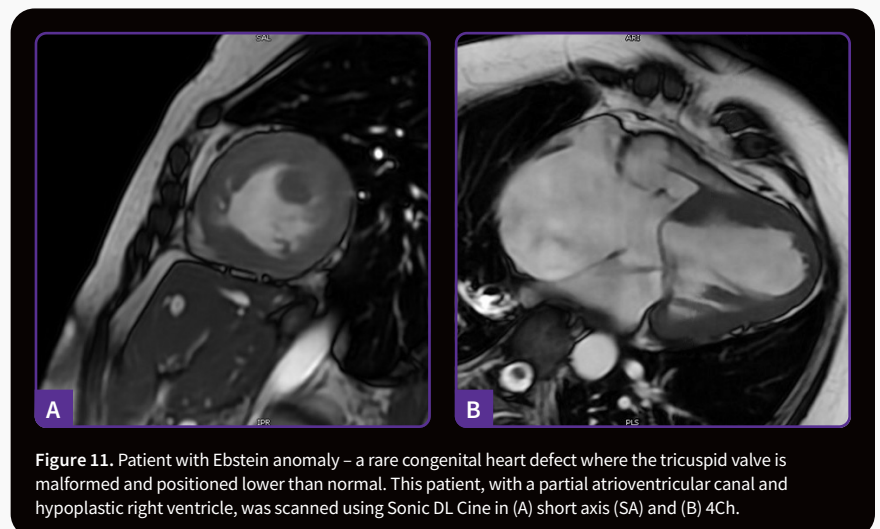


Figure 11. Patient with Ebstein anomaly – a rare congenital heart defect where the tricuspid valve is malformed and positioned lower than normal. This patient, with a partial atrioventricular canal and hypoplastic right ventricle, was scanned using Sonic DL Cine in (A) short axis (SA) and (B) 4Ch.

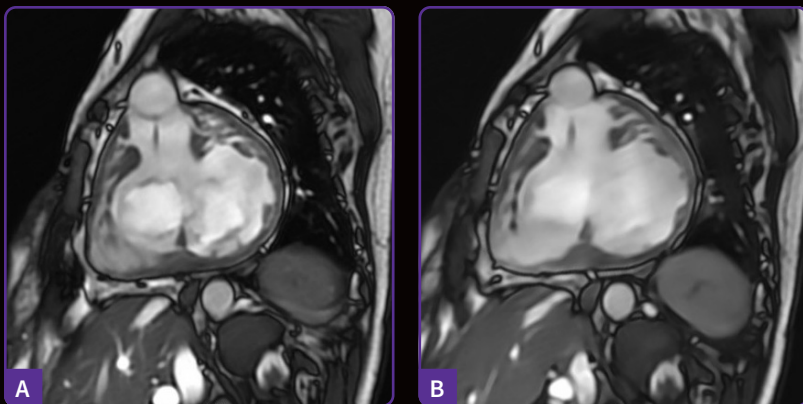


Figure 12. Patient with univentricular heart. A comparison of (A) SA Sonic DL Cine 3 R-R breath-hold and (B) SA Sonic DL Cine 1 R-R free-breathing. The duration of the whole heart scan with Sonic DL Cine 3 R-R breath-hold was 1:40 min, whereas Sonic DL Cine 1 R-R free-breathing was scanned in 1:10 min. The free-breathing method permits acquisition of high-quality images, allowing confident volumetry analysis. Note the similarity in measurements of univentricular, end-diastolic and end-systolic volumes in both approaches.

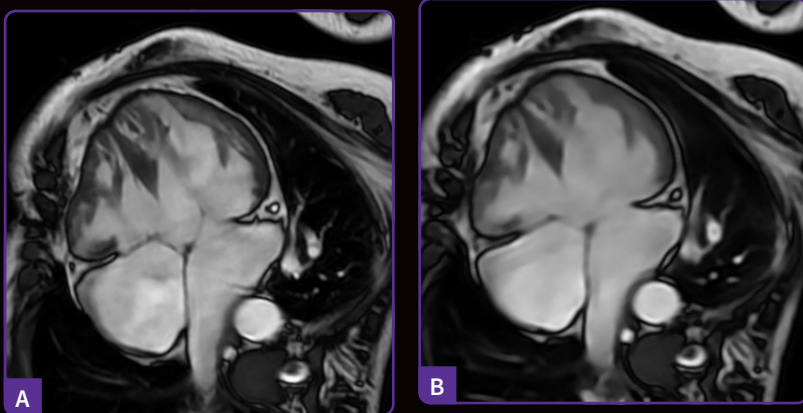


Figure 13. A 36-year-old female patient with a univentricular heart. (A) 4Ch Sonic DL Cine 6 R-R acquisition of 5 slices was done in 30 seconds with breath-hold. The same number of slices was scanned in just 14 seconds with (B) 4Ch Sonic DL Cine 1 R-R free-breathing, representing a reduction of more than 50% in acquisition time.

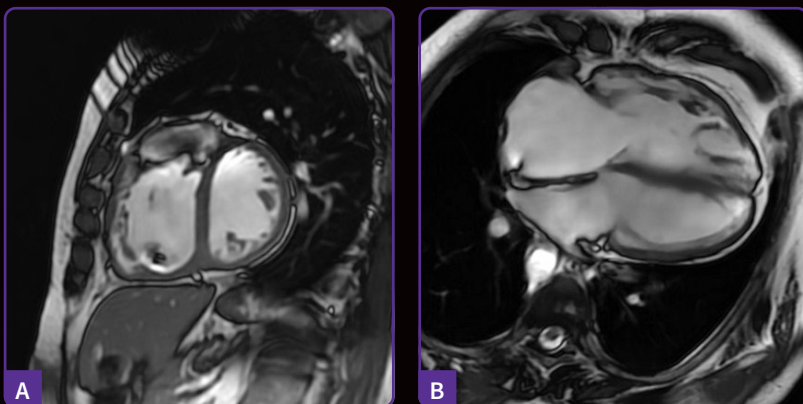


Figure 14. A 45-year-old patient with operated tetralogy of Fallot and an ICD. (A) SA Sonic DL Cine 3 R-R shows an artifact covering the right ventricular outflow tract. The left ventricle has a D-shape with an enlarged right ventricle. (B) 4Ch Sonic DL Cine 6 R-R of the same patient confirms the enlargement of the right ventricle.

months, over 500 CMR examinations were performed, with 5% on adult patients with complex congenital heart defects. In January 2024, the Institute upgraded its SIGNA Artist to MR30.1 for SIGNA™ with Sonic DL Cine.

“It is a very specific and personalized CMR examination in each patient with complex congenital heart disease, which demands more time compared to usual CMR exams,” says Professor Lončar. “That is the value of Sonic DL Cine – we can perform one cine, a short axis stack, in one cardiac cycle. Now, it is possible to acquire in one cardiac cycle sufficient quality to confidently obtain anatomy, volume and ejection fraction calculations and thus reduce the length of this complex acquisition.” It is not uncommon for the center to have one congenital heart disease patient daily referred for CMR.

Prior to Sonic DL Cine, the Institute performed five to six CMR exams in a 12-hour day. Now, they can typically accommodate 11 patients in the same timeframe, doubling their volume for an average of 65 CMR examinations per week, including weekend workload in the last six months. In total, the center performed more than 2,000 CMR exams in 2024.

Professor Lončar hopes to add another MR system to further increase capacity to 22 exams each day and meet the growing demand for CMR examinations.

Before Sonic DL Cine, it was usually difficult – if not impossible – to get sufficiently good quality cine sequences for further confident volumetric analysis in patients with frequent premature ventricular contractions (PVC). Also, atrial fibrillation patients with highly variable heart rates often had non-diagnostic CMR examinations due to poor image quality.

“We tried changing ECG gating from retrospective to prospective to improve image quality, and we would just lose time,” says Professor Lončar. “Now using Sonic DL Cine with 1 R-R, imaging of patients with PVCs or atrial fibrillation is possible in most cases. Usually, in these

cases we go directly to the 1 R-R free-breathing acquisition because we don't want to lose time in the MR scanner, and we see that is not possible to acquire the data we need with a 3 R-R or 6 R-R cine sequence."

Currently, up to 5-10% of the Institute's CMR examinations are these free-breathing acquisitions in patients with arrhythmia and decompensated heart failure. Professor Lončar and Snežana Trajić, MD, cardiologist, will shorten the acquisition times and obtain sufficiently good quality images.

"We have a personalized approach to accommodate every patient. If we have a patient who cannot tolerate laying down for 30-35 minutes in the MR bore, then we modify the protocol and keep it focused to obtain the answer to the clinical question. These improvements with the new software version help us to go faster and obtain sufficiently good quality images for a confident analysis."

The advantages provided by Sonic DL Cine also facilitate imaging of patients with MR-Conditional implanted cardiac devices (Figure 14).

"With a busy electrophysiology department in our Institute, we have many patients with arrhythmias who have pacemakers or implantable cardioverter defibrillators — almost one every day. Sonic DL Cine is the protocol that helps us acquire the data in these patients and makes the exam shorter for them, so that is a big advantage."

Dr. Snežana Trajić

After implementing Sonic DL Cine, Professor Lončar and Dr. Trajić can recall only two patients where the CMR examination was unsuccessful. One was a patient with a pacemaker generator positioned low over the heart, and the other patient had a Blalock-Taussig shunt previously closed surgically with a coil. In both cases, the MR-Conditional implants led to significant artifacts that could not be overcome for a confident diagnosis.

"If we have a question of viability in the anterior segments, sometimes the artifact covers this important region. If it is in the inferior inferolateral, we can make a diagnosis in the majority of cases. Any options that reduce these artifacts from pacemakers or implantable cardioverter defibrillators, such as Wideband MDE, are very important to us."

In addition to Sonic DL Cine, the Institute also uses AIR Recon DL in all compatible sequences. Initially, some clinicians at the Institute were reluctant to embrace it, concerned they may lose some information.

Professor Lončar and a GE HealthCare clinical applications specialist performed an analysis comparing the source images with the AIR Recon DL images to demonstrate the reliability and repeatability of the AIR Recon DL data.

"For me, it was easy to accept from the beginning, but some people needed this evidence. Now, we cannot perform CMR without AIR Recon DL — it sharpens the image and accelerates the exam."

Dr. Goran Lončar

As a result of the advancements to CMR with Sonic DL Cine, the Institute for Cardiovascular Diseases Dedinje can successfully acquire CMR data on nearly any patient with complex cardiovascular disease. It's one more tool enabling the Institute to elevate its CMR service and deliver exceptional patient care. **S**

References

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