

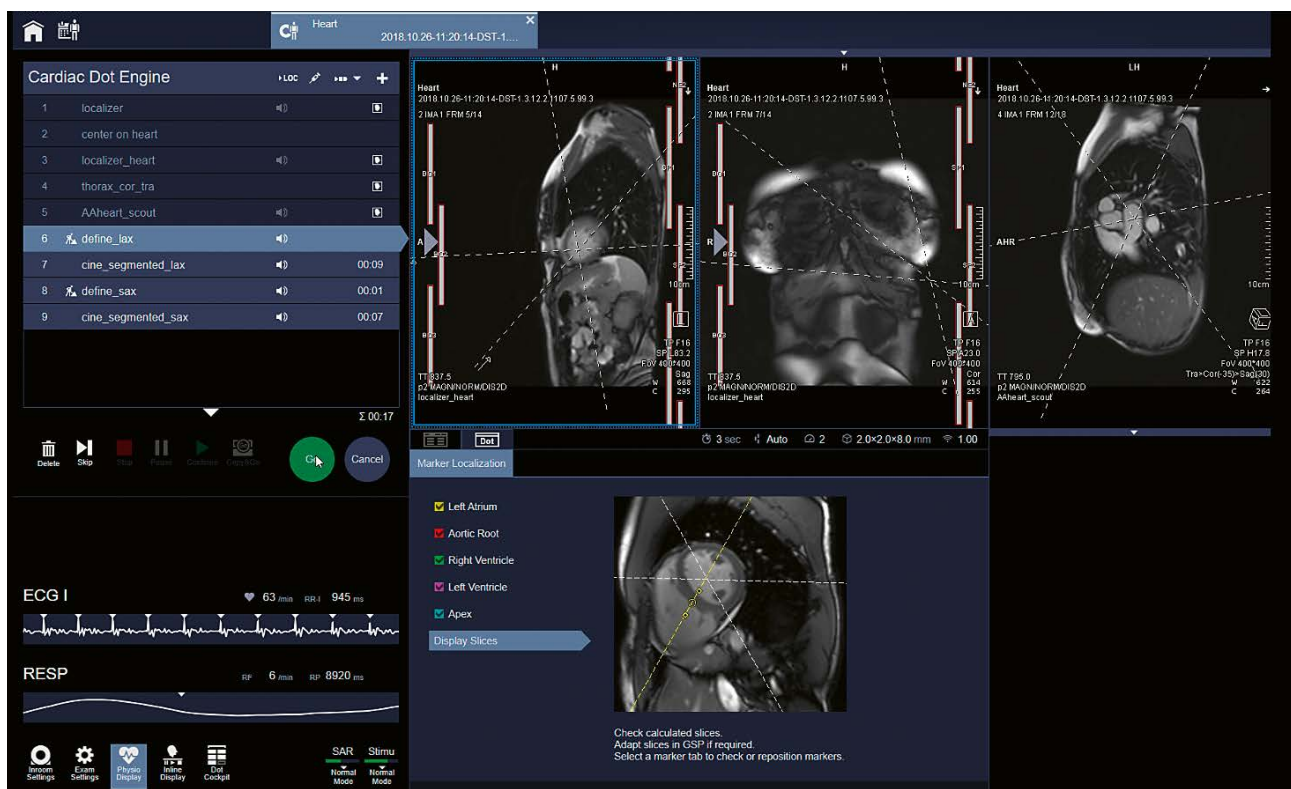
Automated and Standardized CMR Exams Using Cardiac Dot Engine and Short CMR Protocols

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Which cardiac MRI protocol do I use for which purpose? This question remains an unresolved riddle for many users, whether they are new to CMR or are experienced imagers. For many the ease of image acquisition and the quality of the heart views – rarely experienced by any other cardiac imaging modalities – creates a strong temptation to dive deeper and image more. This position is often strengthened by the comparative harmlessness of MRI exams

compared with imaging modalities which require ionizing radiation. However, there is seldom benefit and little clinical evidence that would justify doing more individual scans or introducing additional techniques. In fact, for many patients currently, the most lasting impression of a cardiac MRI scan is how very long it took. What comes to mind for many clinicians is the high cost, relative complexity, and lack of immediate therapeutic benefit.



1 Cardiac Dot Engine
Courtesy of Siemens Healthineers.

It is also important to realize that the complexity of cardiac MRI, with additional scouts as well as planning views and procedures, is unlike that for any other imaging modality. This calls for an efficient core strategy that is first targeted to the clinical question, and, second, supported by validation-qualification evidence. Any additional views need to be used sparingly, if at all, and best regarded as elective views, they need to be decided upon by the attending physician and performed under their direct supervision. In practice, this is often best performed by doctors themselves, which mandates a doctor's own personal scanning capability to competently decide between responsible and (excessive) defensive scanning.

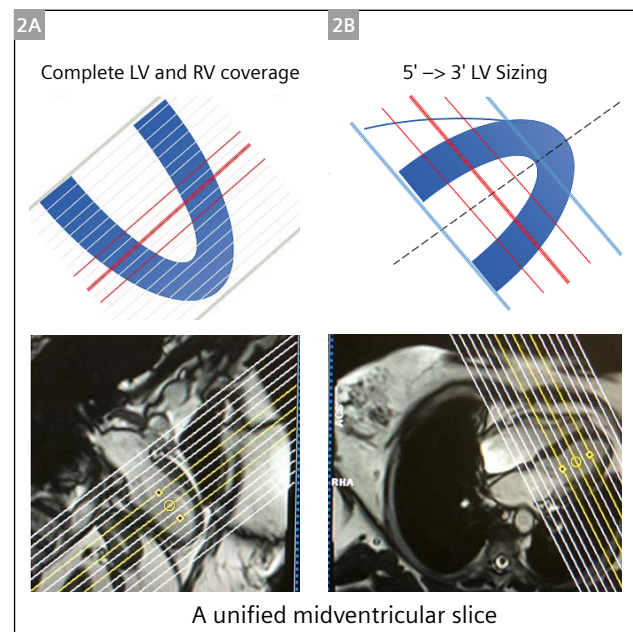
Third, in imaging environments with shared arrangements over equipment and staff where cardiac MRI is squeezed between the 'knees and spines' with an expectation of 'scanning as usual', the opportunity to consider many cardiac-specific issues in patient preparation is often lost. Attending physicians must be integrated into patient preparation, principally to conduct efficient and competent patient communication, as they must make a judgment on the scan plan that fits best to address the clinical question based on a real person and not on paper-based information. Sufficient investment of time to explain the details of the scan procedures and the importance of breath-holding sets the expectations and motivates patients to cooperate positively. A healthy dose of simple humanity, such as in-room presence when administering adenosine or regadenosone is often what defines the outcome in terms of diagnostic image quality and overall patient experience.

At the Institute for Experimental and Translational Cardiovascular Imaging at the University Hospital Frankfurt we have developed Goethe CVI® Cardiovascular Imaging approaches¹ that addressed these considerations in creating standard operating procedures and imaging protocols for everyday use. Notably, our approach greatly benefits from Cardiac Dot Engine technology (Siemens Healthcare, Erlangen, Germany). This highly automated planning tool is, in our view, an essential 'must-have' for cardiac MRI. The Cardiac Dot Engine is based on a traditional feature, the placement of the '3 points' that define a 2-dimensional plane, and as such the imaging slice. There are several advantages to using the Cardiac Dot Engine. First, its built-in automation simplifies cardiac planning steps, thus importantly reducing the overall onboarding training period for new users. Second, although still far from a self-driving experience, planning with the Cardiac Dot Engine can reduce the concentration-burnout from a full day of cardiac scanning, which can require multiple exchanges of personnel. Third, it allows for greater standardization of all procedures, reducing the variation between patient

studies as well as between centers. The Cardiac Dot Engine recognizably reduces the complexity of cardiac scanning, and helps to mitigate the current scarcity of doctors with advanced cardiac MRI training. In centers with more doctors at hand, shorter examination times and overall greater engagement of the doctors allows for their fully autonomous scanning and reporting – as in echo – reducing the reliance on even scarcer radiographer availability.

In the Goethe CVI® exam cards¹, we incorporated a 3-dimensional SSFP localizer allowing for isocenter definition and shim box positioning. This is followed by the Heart Scout, a rough oblique localizer of the heart's position in the chest, which is essentially a combination of the vertical and horizontal long-axis views. Then comes the crucial Cardiac Dot Engine step: Definition of the long-axis views, which involves the positioning of the dots on the relevant anatomical landmarks. This uses a combination of 3 dots per slice to achieve the three true long-axis views for 2, 3, and 4 chambers. These geometries are then acquired as cines. Next comes the short-axis geometry definition, whereby the whole heart stack is planned alongside the subset of 3 short-axis slices (basal, mid, and the apical). Crucially, both are planned perpendicular to the centerline of the long-axis views, with concordance of the middle slice between them. With just these 3 steps, the planning of basic cardiac geometries is complete.

The Goethe CVI® Examcards include acquisition of native maps, (stress-only) myocardial perfusion and late gadolinium enhancement in basic cardiac geometries. The three basic protocols then differ by reductionist approach



2 A unified midventricular slice with (2A) complete LV and RV coverage and (2B) 3' LV sizing.

¹The information shown herein refers to products of a 3rd party and thus are in their regulatory responsibility. Please contact the 3rd party for further information.

to target the clinical question, for instance myocardial perfusion is performed when ischemia is suspected, or microvascular disease is deemed likely based on the pretest likelihood. In practice, most patients will undergo examination with myocardial perfusion imaging, as illustrated by examples of typical patients with either known coronary artery disease (previous stents, ongoing symptoms), those with multiple risk factors (e.g., metabolic syndrome), or systemic conditions where coronary vascular involvement is likely (e.g., systemic lupus erythematosus). Patients with atypical symptoms, commonly profound dyspnoea, will benefit from myocardial perfusion to clarify whether their symptoms correspond with 'angina equivalent'.

Patients with known pathological cardiac anatomy or cardiomyopathies and those who have had previous scans excluding significant myocardial ischemia, however, will undergo shorter protocols without myocardial perfusion. Patients who need repeat scans to follow up on myocardial inflammation/fibrosis and/or volumes/function will undergo native examinations only. Some patients will require a targeted expansion of the core protocols with MR angiography (aorta and renal arteries in hypertension

scans), flows (Qp:Qs) or transaxial slices for congenital indications. The table time of a native scan is approximately 15 minutes, whereas other protocols (with myocardial perfusion and late gadolinium enhancement) are generally completed in under 30 minutes. This is an important contributor to an improved patient experience.

Goethe CVI® Approaches relate to a specific set of standard operating procedures and imaging protocols for cardiovascular magnetic resonance imaging and cardiac contrast tomography in everyday clinical use. Goethe CVI® exam cards are available for use, subject to a sharing agreement and a license fee. This arrangement with us involves two important considerations: First, the quality assurance when importing an exam card, as well as its maintenance to ensure that all functional parameters are preserved as originally envisaged. The second aspect encompasses the hands-on training of users for confident application. We offer several approaches to prospective users, either by Goethe CVI® fellowships or by way of a personalized, week-long observership training in collaboration with Siemens Healthineers. The details are provided on our website.



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