Cardiac Dot Engine: Significant Time Reduction at Cardiac Magnetic Resonance Imaging

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Introduction

Cardiac Magnetic Resonance (CMR) has rapidly developed and is now the technique of choice in the study of multiple heart diseases and an important tool for planning revascularization strategies in patients with coronary artery disease [1]. It allows the assessment of cardiac morphology and function. Therefore, it provides important information about tissue characterization by detecting the first steps of the ischemic cascade through perfusion sequences. An appropriate assessment of myocardial viability can be performed with delayed enhancement sequences [2].

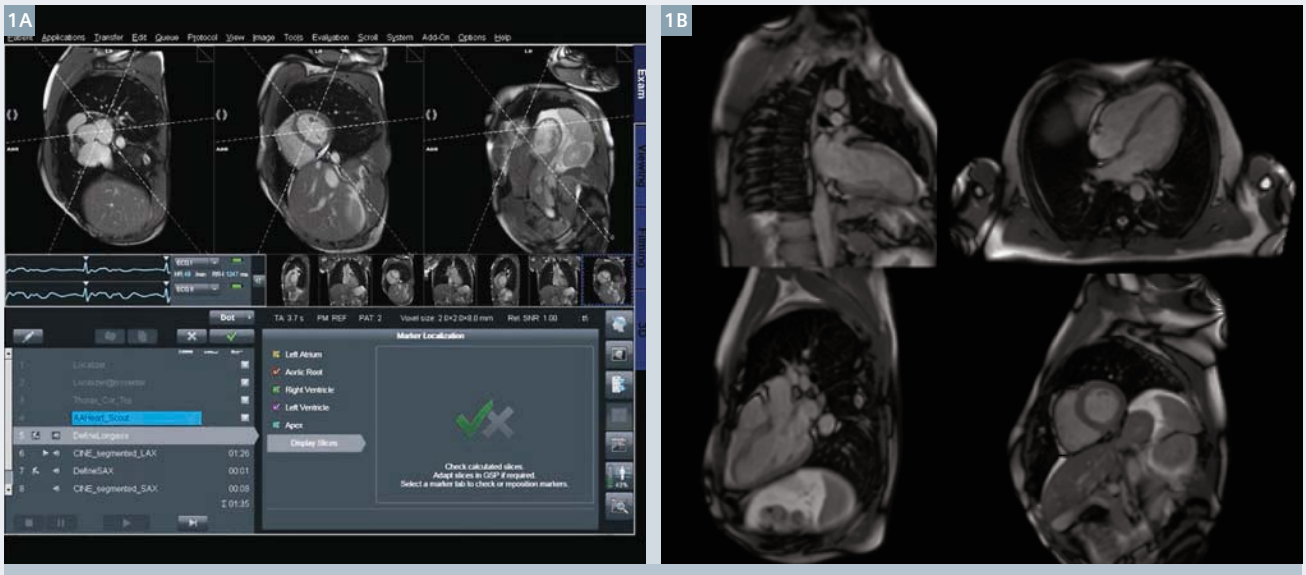
However, CMR is not without certain limitations. Firstly, it requires skilled personnel with a good knowledge of cardiac anatomy and cardiac planes. Secondly, the scan times for CMR studies are substantially longer than for other types of study (with up to more than an hour on stress heart exams) and remain a limiting factor in the recruitment of patients suffering from claustrophobia.

In order to reduce CMR scan times, the Cardiac Dot Engine has been developed. It is a new software technology from Siemens Healthcare, which offers a review of CMR fully guided and suited to the needs of the patient.

The system guides you through a series of graphical illustrations selecting some anatomical reference points on the heart. The software then performs an automatic planning of the different cardiac planes without the need for user intervention. It also allows you to obtain superimposable slices in all sequences of the study, increasing confidence in our diagnoses [3].

Clinical experience

Our experience with the Dot software began in June 2013. To date, we have performed in our center over 272 CMR studies of which 60% are stress studies after administration of adenosine. All



1 Automatic planning of the different cardiac axis with Cardiac Dot Engine.

studies have been performed under medical supervision and have been reproducible and high-quality diagnostic scans. During this time, we have observed a significant reduction of the average scan time.

We therefore proposed the following study to assess the time saved by using the Cardiac Dot Engine in both conventional and stress studies, compared to standard cardiac scans.

Materials and methods

Study design and patients

We have retrospectively reviewed a total of 194 patients consecutively between October 2012 and March 2014 with CMR studies performed at our Siemens 1.5T system (MAGNETOM Aera XQ) with an 18-channel body matrix coil.

For the correct categorization of the study we took into account some variables:

- First, the type of study of stress or conventional CMR. The technical specifications of both protocol studies are summarized in Table 1.
- Second, the use of Short Tau Inversion Recovery (STIR) sequences. We usually use this sequence for patients with suspected acute disease or suspicion of infiltrative heart disease.
- Third, the use of the Cardiac Dot Engine or conventional software.

Depending on the different variables, we obtained eight groups comparing the average scan time with the Cardiac Dot Engine and without it (conventional software).

The total examination time comprises the time from the beginning until the end of each scan.

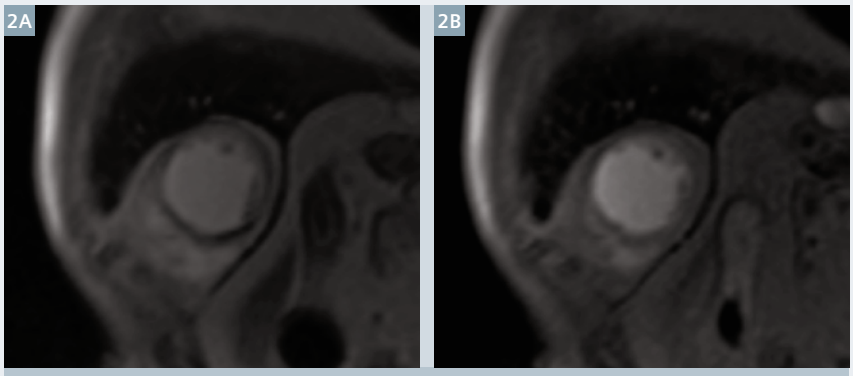
The image quality of the studies has been assessed by a radiologist with over 20 years of experience on a 10-point scale (1 = poor to 10 = excellent).

The statistical analysis has been performed using a Student's T-test for independent samples to compare means. SPSS Statistics software 20.0 (IBM corporation, Armonk, NY, USA) has been used.

Table 1

Conventional CMR	Stress CMR
Localizer	Localizer
HASTE	HASTE
AAHeart-Scout	AAHeart-Scout
Function 4-chamber	Function 4-chamber
Dynamic rest (Gadovist® 0.1 mmol/kg, 4 ml/s)	Dynamic stress adenosine (Gadovist® 0.1 mmol/kg, 4 ml/s)
Function 2 + 3-chamber	Function 2 + 3-chamber
Function short-axis	Function short-axis
Delayed enhancement	Delayed enhancement
	Dynamic rest (Gadovist® 0.1 mmol/kg, 4 ml/s)

Specifications of both study protocols (stress and conventional CMR) performed at our Siemens 1.5T MAGNETOM Aera XQ.



2 MR images show positive findings on stress study in a 53-year-old man with chest pain. The inferolateral wall stress-induced perfusion shows a defect **(2A)** that corresponds with a stenosis involving the left circumflex artery (LCX), disappearing in the dynamic perfusion study **(2B)**.These findings were confirmed on subsequent invasive angiography with successful coronary stenting of the stenosis.

Results

The image quality of all studies obtained a result between 9 and 10.

For conventional CMR studies with STIR sequences (58 patients) statistically significant differences in the average examination time using the Cardiac Dot Engine (t = 39.1 min +/- 12.1) have been observed, reducing the average examination time by 26.5 minutes compared to examination times using conventional software (t = 65.6 min +/- 14.1) (P = .003).

For stress CMR studies with STIR sequences (27 patients) a statistically significant decrease of the examination time has been observed with a reduction of 19.7 minutes (t = 45.11 min +/- 14.7) using the Cardiac Dot Engine compared to (t = 64.9 min +/- 7.8) examination times using conventional software (P = .001).

Furthermore, for CMR studies without STIR sequences (31 patients) a significant mean reduction of the examination time of 15.5 minutes has been found, which has been also statistically significant (t = 57.7 min +/- 14.7) compared to (t = 42.2 min +/- 16.1) (P= .001).

Stress CMR studies without STIR sequences (78 patients) have also shown mean examination times of (t = 44.6 min +/- 16.8) using the Cardiac Dot Engine compared to (t = 65.1 min +/- 22.3) using the conventional software, which means a time reduction of 20.4 min (P = .002) (Table 2).

Discussion and limitations

Our study is not without limitations.

First of all, it is a retrospective study, which has inherent disadvantages.

There are also independent variables that may alter the average examination time. For example, at the time of infusion of adenosine, as a rule, there is a cardiologist present. The mean arrival time of the cardiologist is (t = 4.8 min +/- 7.1), which introduces a considerable delay.

There may also be glitches that force the study to be repeated, although this is very rare. This process, however, rarely extends beyond 5 minutes.

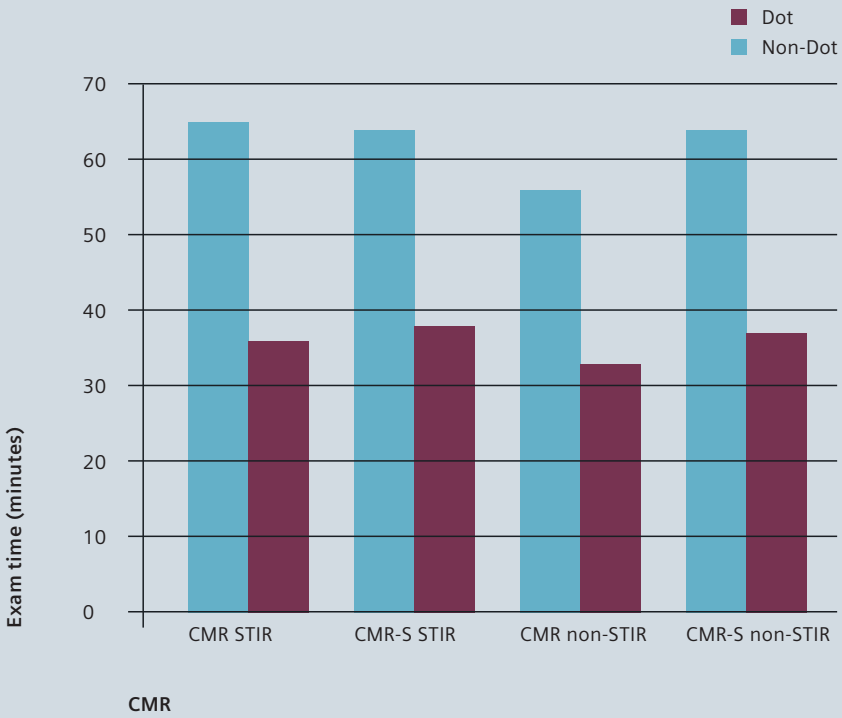
Another factor that may have extended the examination times at the beginning of this study is the universal training of all MRI personnel. It has been observed that during the initial learning phase, after the introduction of the Cardiac Dot Engine, the average examination times have been longer than afterwards. However, once the basic handling of the Dot Engine has been learned, the Cardiac Dot Engine has a fast learning curve without requirement of highly specialized technologists.

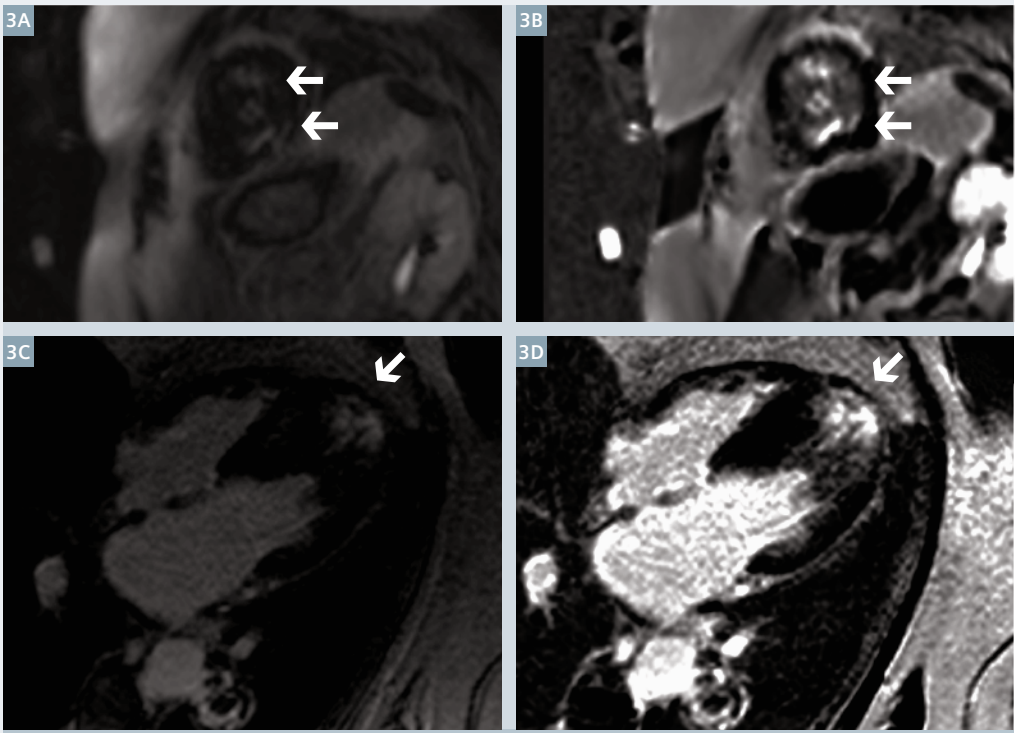
Conclusion

The Cardiac Dot Engine introduces patient benefit by providing systematically reproducible and efficient studies that consistently reduce examination time, resulting in increased efficiency, reduced costs and improved patient satisfaction without ever sacrificing high-quality diagnostic images.

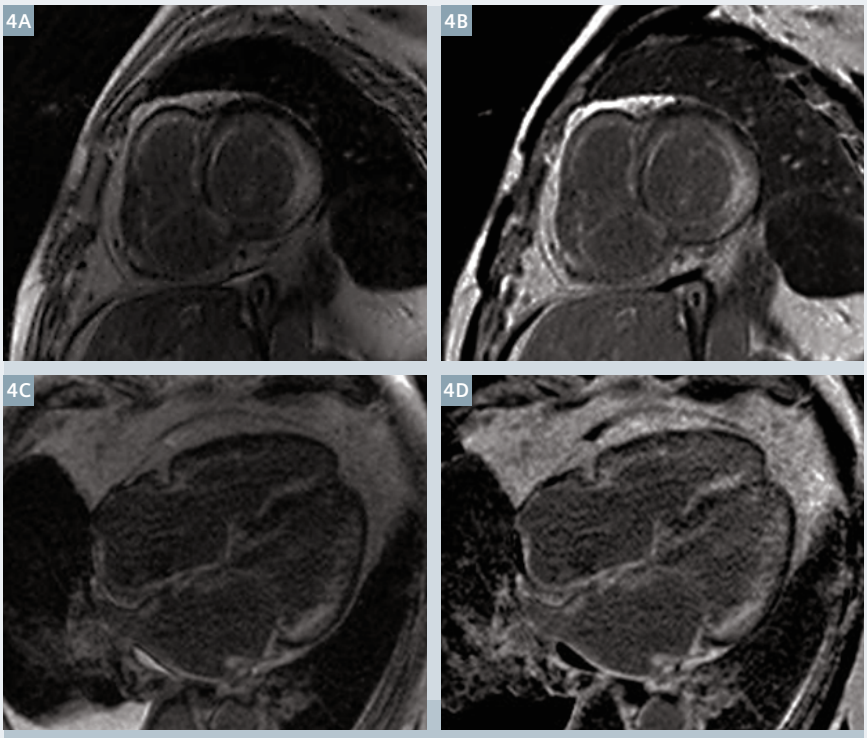
Table 2

Time reduction in cardiac magnetic resonance

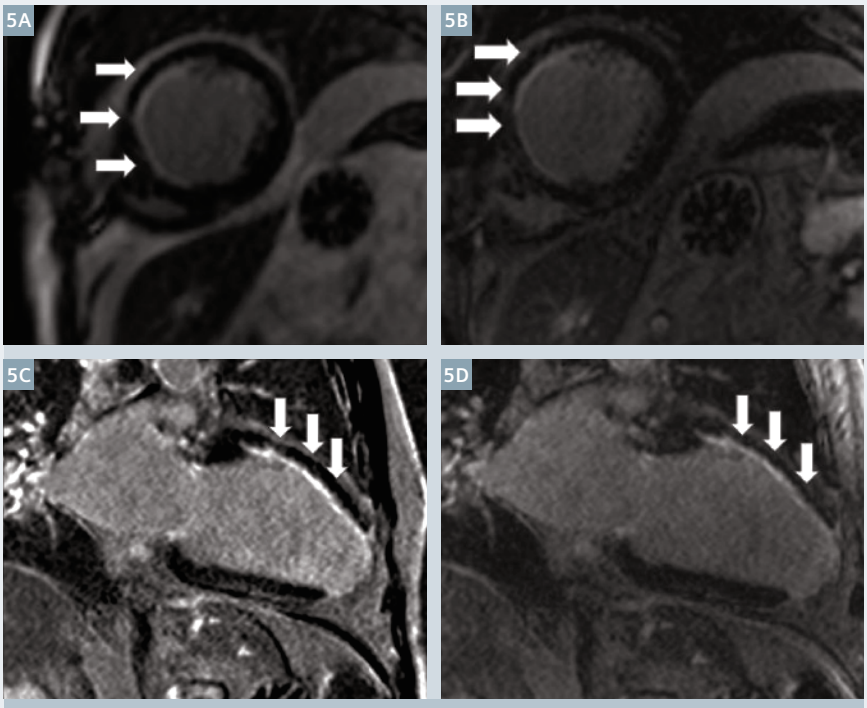




3 Short axis **(3A, B)** and four-chamber-view **(3C, D)** demonstrates hypertrophic changes as well as delayed contrast enhancement in the apex in a 43-year-old man with hypertrophic cardiomyopathy.



4 Delayed enhancement in the short axis **(4A, B)** and four-chamber-view **(4C, D)** reveals the presence of a diffuse patchy enhancement pattern, very suggestive of cardiac amyloidosis in a patient with congestive heart failure. A cardiac biopsy confirmed the diagnosis.



5 **(5A, B)** Short axis and **(5C, D)** two-chamber-view of delayed enhancement sequences. Arrows point to the septal wall of this patient, showing a severe subendocardial hyperenhancement that represents the region of myocardial infarction in the territory of left anterior descending (LAD) and the left circumflex artery (LCX).

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