

Dark Blood Delayed Enhancement MRI for Evaluation of Myocardial Infarction and non-ischemic cardiomyopathy in a Clinical Setting

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Introduction: Delayed enhancement using segmented inversion recovery (IR) TurboFLASH imaging is the clinical gold standard for identifying myocardial infarction. It is also clinically used for assessment of non-ischemic cardiomyopathy [1]. Although this technique allows high contrast between infarct/infiltrate and normal myocardium, it is limited in its evaluation of the subendocardium because of poor contrast between blood pool and subendocardial foci of enhancement. A technique that simultaneously nulls the blood-pool and myocardium would be useful in detecting and evaluating the amount of myocardial delayed hyper-enhancement particularly when it involves the subendocardium. One such technique has previously been described [2-4]. This technique combines a slice-selective saturation (SSSR) or a slice-selective inversion (SSIR) pulse followed by a non-selective inversion (NSIR) to allow simultaneous nulling of both the normal myocardium and the blood-pool. It can improve the contrast between the blood-pool and subendocardial infarct, while still providing adequate myocardium-infarct contrast [2-4]. Similar to standard IR TurboFLASH imaging, when performing the scan a "TI scout" is performed in order to select an optimal TI for nulling of the myocardium. In addition a TI for optimal nulling of the blood pool is selected. The purpose of this study was to use this dark blood late enhancement (DBLE) technique for evaluating patients with myocardial infarction or non-ischemic cardiomyopathy in a clinical setting. Any problems encountered in the day to day running of the technique will be discussed.

Methods: Patients undergoing standard delayed enhanced IR TurboFlash imaging for assessment of myocardial infarction or non-ischemic cardiomyopathy on 1.5T scanner (Avanto, Siemens Medical Systems, Erlangen, Germany) were evaluated. Patients were imaged 10-15 minutes after administration of 0.2m/mol kg of gadopentetate dimegumine (Gd-DTPA). If myocardial hyper-enhancement was detected on the TurboFlash sequence a further TI scout was performed. This allowed adjustment of the optimal TI for myocardial nulling due to prolongation of tissue T1 with increasing delay from contrast injection and selection of the optimal TI for nulling of the blood-pool. Slices were selected to include the area of hyper-enhancement detected on the TurboFLASH images. Contrast to noise ratio (CNR) was calculated (myocardial hyper-enhancement to blood pool and to normal myocardium) by measuring mean signal intensity (SI) and standard deviation (SD) of background signal ventral and lateral to the patient using ARGUS software at a Leonardo workstation (Siemens Medical Solutions). This was calculated for Turbo FLASH and for DBLE:

$$\text{CNR} = [\text{SI hyperenhanced region} - \text{SI normal myocardium or SI blood-pool}] / 1.5 \text{ SD of background signal}$$

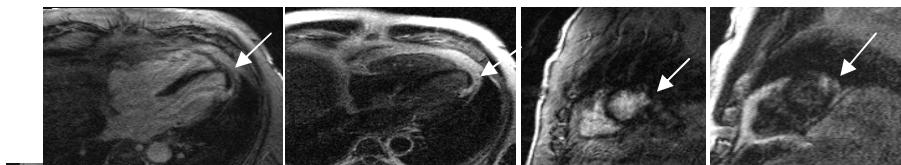


Figure 1. a1) b1) a2) b2)

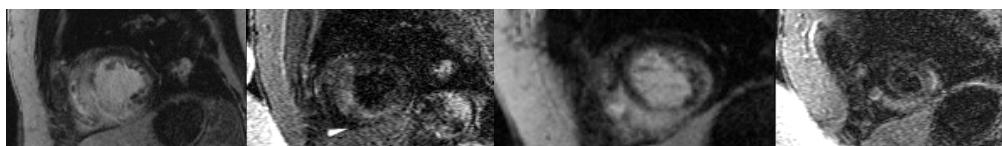


Figure 2 a1) b1) a2) b2)

Results: 12 patients with a subendocardial pattern of myocardial infarction and 10 patients with a clinical history and MRI appearances consistent with non-ischemic cardiomyopathy were evaluated. Figure 1 demonstrates representative findings on a) TurboFLASH and b) DBLE 4-chamber and short axis views for the same patient with an infarct in the apical lateral wall. The calculated CNR between infarct and i) normal myocardium and ii) blood pool was 13.73 and 1.76 (blood was brighter than myocardium) for TurboFLASH and 12.57 and 9.76 for DBLE respectively. Figure 2 demonstrates a patient with myocardial infiltration secondary to sarcoidosis a) Turbo FLASH and b) DBLE short axis images. Note how the scarring extends to involve the subendocardium and how the amount of scarring involving the right ventricular myocardium is more readily appreciated when the blood pool is low signal intensity. The calculated CNR between infiltration and i) normal myocardium and ii) blood pool was 23.33 and -3.33 for TurboFLASH and 6.28 and 7.1 for DBLE respectively. For all patients there was increased CNR between the enhancing myocardium and the blood pool on DBLH compared to TurboFLASH ($p < 0.05$).

Conclusion: DBLE can be used in a clinical setting for evaluation of infarction and non-ischemic cardiomyopathy. Improved CNR between hyper-enhancing myocardium and blood pool can be achieved with acceptable preservation of CNR between hyper-enhancement and normal myocardium.

References: [1] Jackson E, et al. Radiographics 2006 26(3):795-810 [2] Rehwald WG, et al. Proc Intl Soc Mag Reson Med 2007. [3] Salerno M, et al. Proc Intl Soc Mag Reson Med 2007. [4] Rehwald WG, et al. CMR 2007; 101 (abstract 110).