Cine Inversion Recovery (IR): Rapid Tool for Optimized Myocardial Delayed Enhancement Imaging

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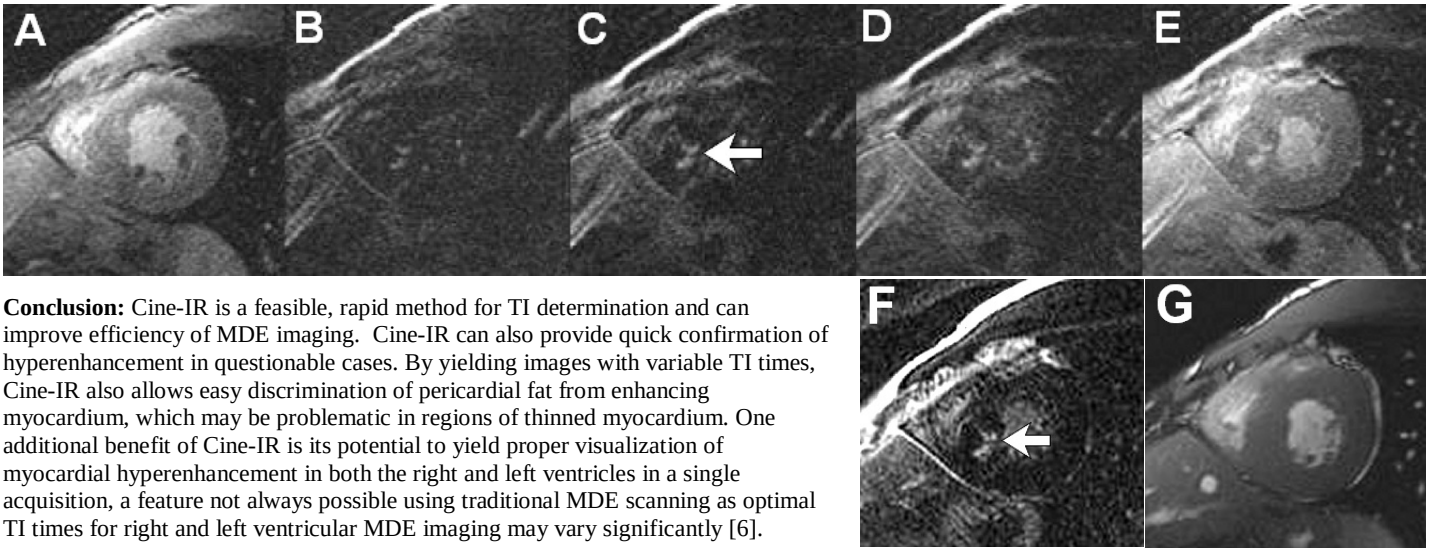
Introduction: Myocardial delayed enhancement (MDE) imaging is a valuable clinical tool for the assessment of patients with a variety of cardiac conditions [1-4]. Initially described for the evaluation of patients with acute and chronic myocardial infarctions, MDE imaging has now been shown to be useful in the evaluation of a larger variety of cardiac diseases such as hypertrophic cardiomyopathy [3,4]. MDE imaging relies on the inherent contrast enhancement differences between normal and abnormal myocardial tissue that occur during the delayed phase (i.e. 10-20 minutes post injection) of a contrast bolus. In MDE images, hyperenhancement — enhancement greater than that of adjacent enhancing normal myocardium — can be seen in regions of myocardial infarction and myocardial fibrosis. Moreover, the extent, pattern and distribution of hyperenhancement within the myocardium have diagnostic and potential prognostic significance.

The detection of hyperenhancement on MDE imaging, however, depends greatly on the ability to distinguish the higher signal within abnormal regions from that of adjacent normal enhancing myocardium. This is typically achieved in MDE imaging by using an inversion recovery (IR) pulse to suppress the normal enhanced myocardial signal. Thus, the key for MDE imaging is proper selection of inversion time (TI). TI selection depends greatly on the underlying myocardial signal, which not only varies over time but can be affected by a number of variables [5] to include contrast media dose and patient factors such as circulatory status, underlying cardiac function and disease state. Improper TI selection can result not only in misdiagnosis but also the repeating of MDE scanning, which can be particularly difficult for older patients as MDE is typically performed during the end of the study when patient tolerance for additional scanning is low. In this study, we evaluate the feasibility of a fast ECG-gated breath-hold technique for rapid TI selection called Cine-IR for MDE imaging.

Methods: Ten patients (age range, 22-77 years; average age = 40 years; 9 males) with suspicion of heart disease were scanned on a 1.5 Tesla MR scanner (CVi, Signa, GE Healthcare, Waukesha, WI) after providing written informed consent for participation in this IRB-approved protocol. All patients underwent routine cardiac evaluation that included ECG-gated cine FIESTA. Following the intravenous administration of a 0.2 mmol/kg dose of Gd-chelate contrast media (ProHance, Bracco Diagnostics), breath-held Cine-IR was performed for selection of optimal TI time. The Cine-IR pulse sequence is an ECG-gated multi-phase segmented fast gradient echo pulse sequence that has a non-selective inversion recovery rf pulse applied at the R-wave trigger. Each image is reconstructed at different phases of the cardiac cycle and has different T1-weighting depending on the time from the R-wave (also the IR pulse). Hence, each image represents not only a different cardiac phase but also a different TI time. Retrospective interpolation was performed on the data to provide full R-R coverage of the cardiac cycle. The optimum TI time was selected based on an evaluation of individual images from the Cine-IR acquisition by an experienced cardiac imager. Using the TI time determined by review of the Cine-IR images, breath-held MDE imaging was performed using a 2D segmented k-space ECG-gated IR-prepared fast gradient echo acquisition.

Results: Breath-hold Cine-IR was successfully performed and afforded rapid TI determination in all patients. Diagnostic-quality MDE images were obtained in all subjects. Representative Cine-IR and MDE images are shown in Figure 1. The ability to review a set of images at varying TI times also provided improved confidence in identifying hyperenhancement as Cine-IR yields both wall motion and differences in T1 as contrast mechanisms.

Figure 1. 25-year-old Man with Hypertrophic Cardiomyopathy. A-E: Five images selected from a 40-phase short-axis Cine-IR acquisition (TR 5.2 msec/TE2.4 msec; Fig. A, 57 msec; Fig. B, 177 msec; Fig. C, 207 msec; Fig. D, 237 msec; Fig. E, 407 msec) through the left ventricle shows the variable signal of normal myocardium and patchy hyperenhancing regions (arrow), most probably fibrosis, within the hypertrophic inferoseptal myocardial wall. Optimal signal difference (image contrast or "conspicuity") between the hyperenhancing regions and normal myocardial tissue was noted at 207 msec (Fig. C). **F:** Subsequent 2D MDE imaging (TR 5.5 msec/TE 1.4 msec/TI 207 msec; Fig. F) confirms hyperenhancement (arrow) within the middle of the thick inferoseptal wall. **G:** Corresponding pre-contrast short axis FIESTA image for comparison.



Conclusion: Cine-IR is a feasible, rapid method for TI determination and can improve efficiency of MDE imaging. Cine-IR can also provide quick confirmation of hyperenhancement in questionable cases. By yielding images with variable TI times, Cine-IR also allows easy discrimination of pericardial fat from enhancing myocardium, which may be problematic in regions of thinned myocardium. One additional benefit of Cine-IR is its potential to yield proper visualization of myocardial hyperenhancement in both the right and left ventricles in a single acquisition, a feature not always possible using traditional MDE scanning as optimal TI times for right and left ventricular MDE imaging may vary significantly [6].

References: **1.** Kim RJ, et al. ***N Engl J Med*** 2000;343:1445-1453. **2.** Gerber BL, et al. ***Circulation*** 2002;106:1083-1089. **3.** Moon JCC, et al. ***JACC*** 2003;41:1561-1567. **4.** Kim RJ, Judd RM. ***JACC*** 2003;41:1568-1572. **5.** Peterson SE, et al. ***J Cardiovasc MR*** 2004;6:541-548. **6.** Desai MY, et al. (abstr.) ***J Cardiovasc MR*** 2004;6:63-64.