Determining the Partition-Coefficient of Gd-DTPA in Patients with Reperfused Myocardial Infarction: Delayed Enhancement vs. Constant Infusion Techniques

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INTRODUCTION:

MRI with Gd-DTPA has emerged as a powerful tool in the assessment of myocardial viability. The hyperenhancement of infarcted myocardium has been attributed to the 2-3 fold increase in the partition-coefficient of Gd-DTPA (λ) in infarcted (relative to normal) tissue.[1] Historically, the most popular approach to performing viability imaging with Gd-DTPA has been a technique known as "Delayed Enhancement Imaging" (DE), where imaging is performed at a fixed time interval following a bolus injection of the tracer. The constant-infusion (CI) technique also begins with a bolus injection of tracer although, with this approach, the bolus is immediately followed by a prolonged (>30 min) infusion at a constant dose; the addition of the infusion allows for the direct quantification of λ.[1] Of particular concern was to determine the extent to which DE images reflect λ with injection time and maturity of scar. Previous work in canines demonstrated that DE images were strongly dependent on λ, soon after reperfusion.[2] To address these questions in the clinical setting, patients with reperfused myocardial infarction (MI) were recruited to compare CI and DE estimates of λ, both early (3-4 weeks) and late (6 months) post MI.

METHODS:

Both DE and CI imaging techniques were applied to patients with reperfused MI (n=6, one female; mean age=64 +/-11.8 yr; mean body mass=87.8 +/-15.0 kg) at 3-4 weeks ('Early' scans). DE and CI sessions were performed on separate days, 3 or 4 days apart and in random order. All patients returned for both DE and CI imaging again approximately 6 months post-MI ('Late' scans). All MR imaging was performed in a Siemens Vision 1.5 T scanner. ***CI imaging:*** a bolus (0.2 mmol/kg b/w) of Gd-DTPA was injected and followed immediately by a 45-60 min CI (0.004 mmol/min/kg b/w). Enhancement was followed using a saturation recovery TurboFLASH sequence (srTFL, TR/TE 2.4/1.2ms, α=15, full LV coverage, short-axis orientation). Images were acquired prior to Gd-DTPA and then repeated at 3-5 min intervals. ***DE imaging:*** a bolus (0.2 mmol/kg b/w) Gd-DTPA was administered and enhancement followed with serial srTFL imaging, up to 30 min post-bolus. ***Image analysis:*** using AnalyzeAVW software (Mayo Clinic, Rochester, MN), the epicardial and endocardial LV borders were segmented in each slice and then further divided into two rings; each ring was in turn divided into 8 segments, for a total of 16 LV tissue regions of interest (ROIs). A 17th ROI was located in the LV blood-pool. For each tissue ROI in the DE srTFL image set (for all times post-bolus), λ_{DE} was estimated by the ratio of the change in signal-intensity (SI) in the myocardium ([pre-post] contrast) to the change in SI in the blood. The slice-equivalent ROI map was then applied to the end-CI (equilibrium) srTFL images, in order to calculate λ_{CI}. For each DE time (2-30 min post-bolus), λ_{DE} was compared with the λ_{CI} in the equivalent CI srTFL ROI, and a concordance coefficient, Rc, was calculated. A repeated measures ANOVA (α=0.05) was used to assess the effects of DE time and time post-MI (Early or Late) on Rc.

RESULTS:

Areas of hyperenhancement were observed in all patients studied. There was a strong correlation between the Early λ_{CI} values and the λ_{CI} obtained at the Late follow-up (Pearson's R=0.74, slope=0.74, p<0.01). Overall, there were no significant changes in λ_{CI} between the Early and Late scan times (p=0.36). Similarly, multiple comparisons revealed no significant differences in λ_{DE} based on either DE time (2-30 min, p=0.75), or time post-MI (Early or Late, p=0.51). The average λ_{DE} values for all patients and for both Early and Late components are shown with respect to DE time in Fig. 1. Examining the agreement between λ_{DE} and λ_{CI} for all patients, there was no significant change in Rc between Early and Late studies (p=0.72). Although the choice of DE time had a small effect on Rc overall (p=0.02), the average Rc was consistently greater than 0.80 for all DE times >4 min post-bolus (Fig. 2). There was no significant interaction between the time post-MI and the choice of DE time (p=0.15).

Fig. 1: Average λ_{DE} +/−SEM for image delay times (DE time)=2-31 min

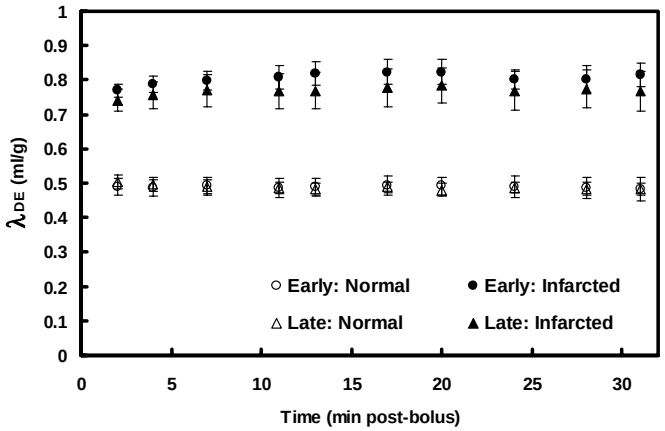
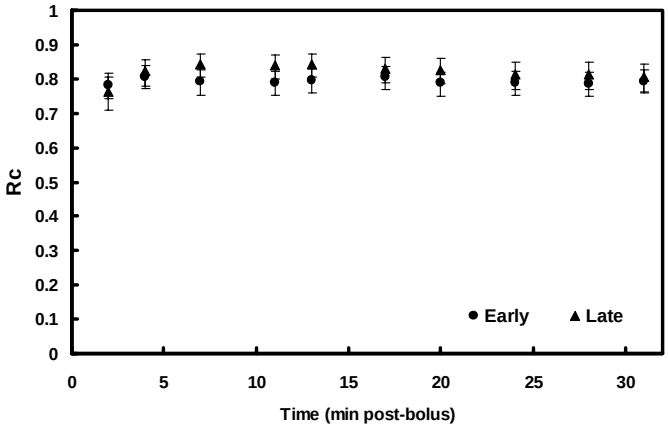


Fig. 2: Average Rc (+/-95% CI) for DE time=2-31 min



DISCUSSION:

In this study, both DE and CI techniques for the MR assessment of myocardial viability were applied to the same group of patients, both early and late post-MI. CI estimates of the partition-coefficient of Gd-DTPA were remarkably stable between early and late scan sessions. This in turn suggests that the extravascular/extracellular fraction changed very little between 3-4 weeks and 6 months post-MI.

The concordance between DE and CI estimates was used as a means of determining the extent to which DE images reflect λ. Concordance between the DE and CI techniques was reasonable for most choices of DE time, and this did not appear to change at 6 months follow-up. Effectively, this means that the contrast enhancement observed by DE is a very good reflection of λ. The results presented here are consistent with earlier findings in canine models of reperfused MI.[2] This work is of potential importance, as Gd-DTPA-enhanced MRI is quickly supplanting older techniques for the quantification of myocardial viability. This study will contribute to our understanding of how patients can best be served with contrast-enhanced MRI.

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