Optimization of Contrast Medium Administration for First-pass Myocardial Perfusion at 3T MR System

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Introduction

MR-based myocardial perfusion measurement is performed with paramagnetic contrast medium (CM) to detect flow-limited stenosis in the coronary artery [1]. Currently, MR myocardial perfusion is assessed in either qualitative or quantitative methods. For qualitative assessment, high CM dose is preferred to produce better contrast-to-noise ratio (CNR) and to improve detection of perfusion defect. In model-dependent quantitative analysis, however, both the linearity between CM dose and signal intensity (SI) and adequate bolus contrast should both be met to ensure reliable tracer kinetic assessment. Although administration of CM for myocardial perfusion study has been optimized at 1.5T, it may be different at 3T MR system due to inherent differences in T1/T2 relaxation times. Therefore, the purpose of this study was to determine the optimum protocol of CM administration for quantitative analysis of myocardial perfusion at 3T MR system.

Materials and Methods

MR acquisition

Seven healthy volunteers (N=7) received first-pass contrast-enhanced MR studies at a 3T MR scanner (Trio, Siemens, Germany). Five different CM doses (Gd-DTPA at dosage of 0.0125, 0.025, 0.05, 0.075 and 0.1mmole/kg body weight) were bolus injected via left antecubital vein in different sessions of data acquisition. We tested two different protocols of CM administration. One protocol (N=1) fixed the injection rate at 4ml/sec and the other protocol (N=6) fixed the injection time at 1.5 sec. Three short-axis slices at basal, mid left ventricle (LV) and apical levels were acquired using SR-Turbo FLASH pulse sequence, TR/TE/FA = 160 ms/0.98 ms/10°, spatial resolution = 2mm, temporal resolution = 1 R-R interval and the total number of time frames = 80. To avoid dose accumulation, neighboring data acquisition sessions were separated 30 min apart to ensure clearance of CM from the blood.

Data analysis

LV myocardium and cavity were segmented semi-automatically. Baseline images acquired before contrast arrival were used to correct for the depth-dependent signal variation due to employment of surface coils. The first-pass signal time curve from the LV myocardium and cavity were measured at each time frame in five different doses (Fig. 1). From the signal time curves, peak SI, SNR (Peak SI / STD of background noise) and CNR ([Peak SI – baseline SI] / STD of baseline SI) in the LV myocardium and cavity were measured at 5 different doses.

Results

For the protocol of fixed injection rate, higher CM doses prolonged the bolus duration, broadened the first pass and made fitting results unstable [1]. For the protocol of fixed injection time, peak SI, SNR and CNR in the LV myocardium increased linearly with CM dose over the whole range of dosage. In contrast, the same parameters in the LV cavity increased linearly up to 0.05 mmole/kg, and showed saturation or even attenuation from 0.05 to 0.10 mmole/kg (Fig. 2).

Conclusion

In this study, we evaluated different protocols of CM administration for myocardial perfusion at 3T MR system. We found that not only CM dosage but also injection duration were crucial to achieve linearity of CM dose with respect to SI and to maintain adequate bolus contrast. Our study suggests that Gd-DTPA of less than 0.05 mmole/kg and injection duration of less than 2 sec are optimum for quantitative analysis of myocardial perfusion study at 3T MR system.

References

[1] Atkinson DJ, Burstein D, Edelman RR. First-pass cardiac perfusion: evaluation with ultrafast MR imaging. Radiology 1990;174:757-762.

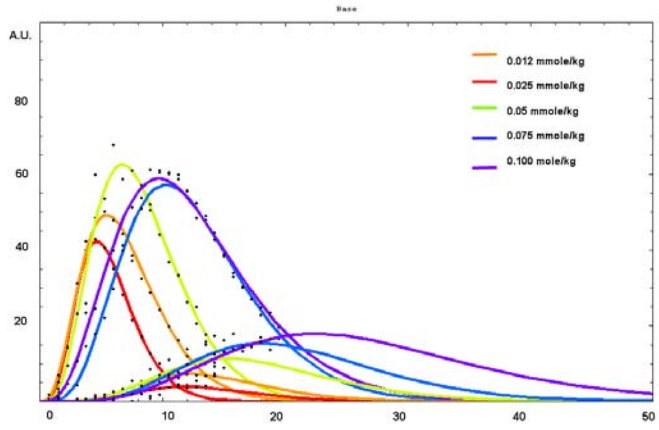

Fig 1: Signal intensity (SI) curves of the LV cavity and myocardium at 5 different doses. In the low dose regime from 0.0125 to 0.05 mmole/kg, the upslope is constant and Peak SI increases proportionally with doses. In high dose regime (>0.05 mmole/kg) upslope is no longer constant and saturation of Peak SI occurs.

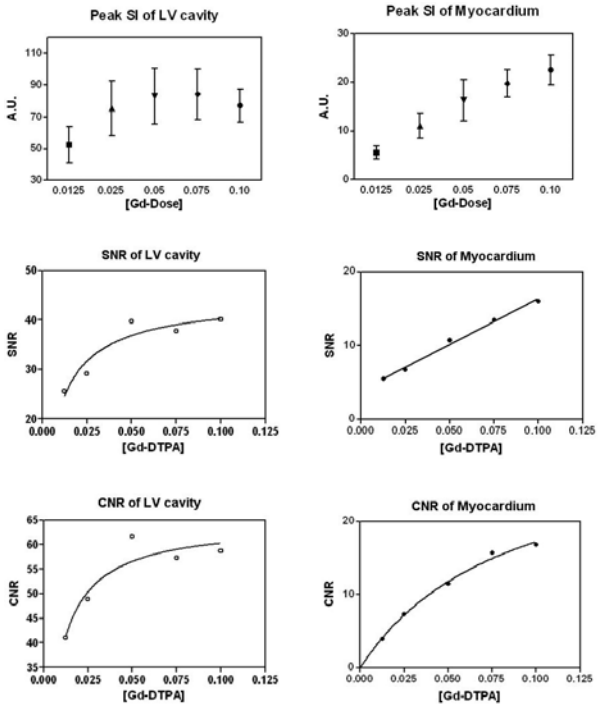

Fig 2: Peak SI, SNR and CNR for LV cavity and myocardium at different CM dosages.