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Meeting abstract

114 The Relationship between signal intensity and myocardial gadolinium concentration for three MR perfusion pulse sequences: implications for measuring absolute myocardial blood flow

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Background

Absolute myocardial blood flow (in ml/min/g) can be calculated from CMR first-pass perfusion studies by model-based deconvolution of the left ventricular blood pool and myocardial signal intensity-time curves. This technique is increasingly being applied to calculate myocardial blood flow in various cardiovascular diseases [1-3]. A basic assumption of the deconvolution technique is that signal intensity is proportional to gadolinium concentration in both the blood pool and myocardium. Dual-bolus [4] and dual-echo [5] techniques have been proposed to address the known nonlinear signal response of the blood pool to gadolinium. Based on phantom studies or signal response to escalating Gd dose, recent reports suggest that despite its low signal, the myocardial response to gadolinium is also nonlinear [6,7]. The myocardial signal response to myocardial gadolinium concentration needs to be defined for common perfusion pulse sequences to guide the appropriate application of absolute perfusion measurements by deconvolution.

Purpose

We sought to define the relationship between myocardial signal response and myocardial gadolinium concentration for three pulse sequences: 1) saturation recovery-prepared segmented echo-planar-imaging (SR-EPI), 2) saturation recovery-prepared turbo fast low-angle shot (SR-FLASH), and 3) inversion recovery-prepared single-shot steady-state free-precession (IR-SSFP).

Methods

Imaging was performed in two purpose-bred hounds, chronically instrumented with left atrial, right atrial, and aortic catheters on a 1.5 T clinical MR scanner (Siemens Sonata). As regional gadolinium concentration can be calculated from the longitudinal relaxation rate (1/T1), cardiac T1 can therefore be measured from T1 mapping performed using a modified Look-Locker technique (MOLLI) [8]. During a constant slow infusion of Gd, a single mid-ventricular short axis slice was alternately imaged for 1) signal intensity by SR-EPI, SR-FLASH, or IR-SSFP and 2) T1 mapping (MOLLI). Infusion experiments were performed with an infusion rate of 0.5 mmol/min in order to span the myocardial signal range expected in response to a 0.05 mmol/kg IV bolus. Signal intensity values were normalized to correct for coil inhomogeneity and the baseline signal. The increase in normalized signal intensity and gadolinium concentration were plotted against the time of infusion. The signal intensity and gadolinium concentration curves as functions of time were interpolated using a cubic spline technique to generate a parameterized signal intensity response curve as a function of gadolinium concentration.

Results

The relationship between signal intensity and gadolinium concentration was nonlinear for SR-EPI and SR-FLASH, resulting in underestimation of gadolinium concentrations higher than 0.5 mmol/L. IR-SSFP was linear over the full range of gadolinium concentration tested. At a gado-

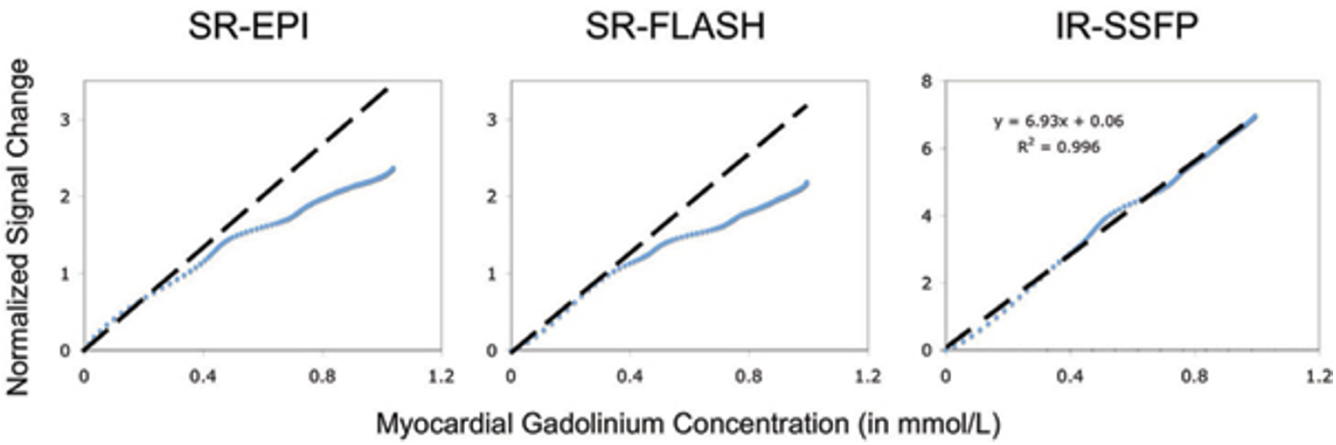

Figure 1
The relationship between myocardial signal intensity and gadolinium concentration affects absolute blood flow calculation. It is linear for inversion recovery steady state free precession but nonlinear for saturation recovery echo planar imaging and turbo fast low angle shot perfusion sequences.

linium concentration of 1 mmol/L, the relative signal increase over baseline for SR-EPI, SR-FLASH, and IR-SSFP were 2.4, 2.2, and 7.0 respectively. Figure 1 illustrates the signal response for each pulse sequence.

Conclusion

The relationship between myocardial signal intensity and gadolinium concentration depends on the first-pass perfusion pulse sequence used. IR-SSFP demonstrates excellent myocardial signal enhancement and is linear over the range expected for a 0.05 mmol/kg bolus. Over the same range, SR-EPI and SR-FLASH exhibit less robust myocardial signal enhancement and a nonlinear response to gadolinium concentration. The nonlinear signal response of SR-EPI and SR-FLASH needs to be accounted for to avoid underestimation of absolute myocardial blood flow by model-based deconvolution.

References

1. Selvanayagam , *et al.*: *Circulation* 2005, **112:**3289-3296.
2. Petersen , *et al.*: *Circulation* 2007, **115:**2418-2425.
3. Wang , *et al.*: *J Am Coll Cardiol* 2006, **47:**565-572.
4. Christian , *et al.*: *Radiology* 2004, **232:**677-684.
5. Gatehouse , *et al.*: *J Magn Reson Imaging* 2004, **20:**39-45.
6. Weber , *et al.*: *J Magn Reson Imaging* 2007, **26:**569-579.
7. Utz , *et al.*: *J Magn Reson Imaging* 2007, **25:**1131-1135.
8. Messroghli , *et al.*: *Magn Reson Med* 2004, **52:**141-146.