Correction for T1-Nonlinearity in Myocardial Signal Intensity Improves First-Pass Perfusion Quantification

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INTRODUCTION

The nonlinear T1 saturation recovery in first-pass contrast-enhanced MR myocardial perfusion imaging is an important issue which affects quantification of myocardial blood flow. Despite many efforts focused on improving the linearity of the LV blood pool signal intensity, relatively little work has been published with regard to nonlinearity in the myocardium.

PURPOSE

We hypothesize that 1) T1-nonlinearity is significant in the myocardium and it will affect both semi and fully quantitative perfusion estimates, 2) this nonlinearity will affect a long saturation recovery delay more than a short one, 3) a nonlinear correction of the myocardial signal intensity will improve quantitative perfusion estimates, 4) semiquantitative perfusion indices underestimate perfusion independent of T1-nonlinearity.

METHODS

Ten normal volunteers went through 40 dual-bolus (Gd-DTPA 0.005 and 0.1 mmol/kg) perfusion studies on a 1.5T Siemens Espree scanner to cover the interplay of rest vs. stress states and short vs. long saturation recovery delays (TD 70 and TD150 ms) for quantitative perfusion estimates. Rest perfusion was performed 4 hours after the dipyridamole (0.56 mg/kg over 4 minutes) stress study. The nonlinear T1-nonlinearity between TD150 and TD70 was more severe for TD150 than TD70. (b) Comparison of time intensity curves before and after the LUT correction revealed more severe signal intensity distortion for TD150 than TD70, particularly at the time period near the peak myocardial contrast concentration (from 12 to 20 seconds along the time axis).

RESULTS

Table 1 summarizes the results of fully and semiquantitative perfusion quantification. For this interstudy comparison, the MBF estimate of TD150 correlated well with TD70 after the LUT correction (R2=0.87). The correlations were worse for CER and SLP. All perfusion estimates were compared with the TD70 MBF estimate after the LUT correction. The dashed line indicates the expected line of identity for perfusion indices that would increase proportionately with the change in MBF from rest to stress.

CONCLUSIONS

The effect of T1-nonlinearity between myocardial signal intensity and contrast concentration significantly affects perfusion quantification. This nonlinearity leads to underestimation of all quantitative perfusion measures studied. The effects are more severe for TD150 than TD70. A LUT correction based on acquisition specific relaxivity models of signal intensity versus contrast concentration can correct the signal intensity curves for perfusion quantification. However, semiquantitative perfusion indices still underestimated vasodilated blood flow despite correction of the T1 nonlinearity.