In-vivo T2* effects in the dual-sequence method for first-pass myocardial perfusion MRI
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Aim
To examine whether T2* effects in large pixels reduce the accuracy of arterial input function measurement in the left ventricle, which would distort myocardial perfusion measurement by the “dual sequence” method.

Introduction
Measuring myocardial perfusion requires accurate arterial input function (AIF) and myocardial tissue response function measurements, ideally during the same first-pass of Gd-based contrast agent. The “dual-sequence” method (1) obtains high T1-sensitivity high-resolution myocardial images and a low T1-sensitivity (and low-resolution, so very quick) left-ventricular blood image in the same cardiac cycle (Figure 1). The method aims to maximize myocardial CNR and eliminate AIF peak distortion (due to full T1-recovery) for improved perfusion accuracy (2.3).

The larger voxels (10 x 6 x 6mm) of the fast AIF sequence are more subject to T2* effects, compared to a typical myocardial imaging voxel size (e.g. 8 x 2 x 2mm). Large voxels have a greater distance over which B0-inhomogeneity can dephase the signal. (Conversely, the shorter echo-time and faster echo-sampling of the AIF sequence reduce its sensitivity to dephasing). The bolus of paramagnetic CA may significantly distort B0 at the peak LV blood concentration, even though well below 10mM from a fast antecubital 0.1mmol/kg injection at 0.5M. It was therefore necessary to test for T2* effects in-vivo.

Method
In 10 patients with varying degrees of coronary artery disease, 140ug/kg/min adenosine stress first-pass short-axis imaging was performed (0.5M Magnnevist, 0.1mmol/kg, 7ml/s, 10ml saline flush) repeated >20 mins later at rest. The dual sequence method used FLASH for the AIF image (TR1, TE0.5ms, FA10, 6x6mm, 64x48raw, 3900Hz/pixel) in the same plane as the middle of the three TSENSE (R2 avg 8) 4-ETL kyentre-out hybrid-EPI myocardial slices (TR5.8, TE1.2, FA30, 8x2.7x2.7mm, 1860Hz/pixel, 116ms/image starting after 50ms SR delay) acquired in each cycle. To minimise T1-weighting in the AIF image, its non-selective saturation pulse was disabled and the FLASH ky-ordering was centre-out.

(method continued) Magnitude images were reconstructed without filtering, ensuring constant receiver gains and reconstruction scaling factor for all 50 cardiac cycles. Each EPI-image was preceded by non-selective saturation so that myocardial perfusion abnormalities were reported clinically as usual. A circular ROI-mean in the LV of the AIF image was measured, of maximum diameter avoiding papillary muscles etc, moving the ROI to track in-plane components of respiratory motion. For each patient’s rest and stress studies separately, the highest ROI-mean value found during bolus transit was compared with the value in the first image.

Results and Discussion
With no T2* loss and negligible T1 and T2-sensitivity, the ROI value at the high CA concentration (bolus peak) should be 100% of the ROI value obtained without CA i.e. before bolus arrival. In the patients, this bolus-peak-to-initial ratio was 98%+/-3% (mean+/-stdev). The ROI-mean plotted against cardiac-cycle (example, Figure 2) was complicated by the saturation pulses for the myocardial slices, and by the varying delay before the next cycle’s AIF image due to RR-interval variations. For the relevant data, this did not matter: the first AIF image ran before any saturation pulses, and for the bolus peak, the short blood T1 caused full-recovery before the AIF image.

The dual-sequence AIF image has no measurable attenuation of the LV bolus peak blood signal at high-dose with fast injection, indicating that T2* would affect only a significantly more sensitive combination of large voxel size and long TE. This work removes concerns that the dual-sequence method might be erroneous due to T2*.

Conclusions
The dual-sequence AIF image has no measurable attenuation of the LV bolus peak blood signal at high-dose with fast injection, indicating that T2* would affect only a significantly more sensitive combination of large voxel size and long TE. This work removes concerns that the dual-sequence method might be erroneous due to T2*.

References