Slow infusion improves precision of liver function measurements by DCE-MRI

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BACKGROUND: Quantitative dynamic contrast-enhanced (DCE) MRI with a rapidly injected bolus of gadoxetate can be used to quantify liver perfusion and transporter function [1,2]. Measuring these rapid changes requires high temporal resolution, and this involves compromises in spatial resolution, coverage or SNR. However, when the aim is to measure hepatocellular function (a slow process), rather than perfusion (a fast process), there is no rationale for a rapid injection.

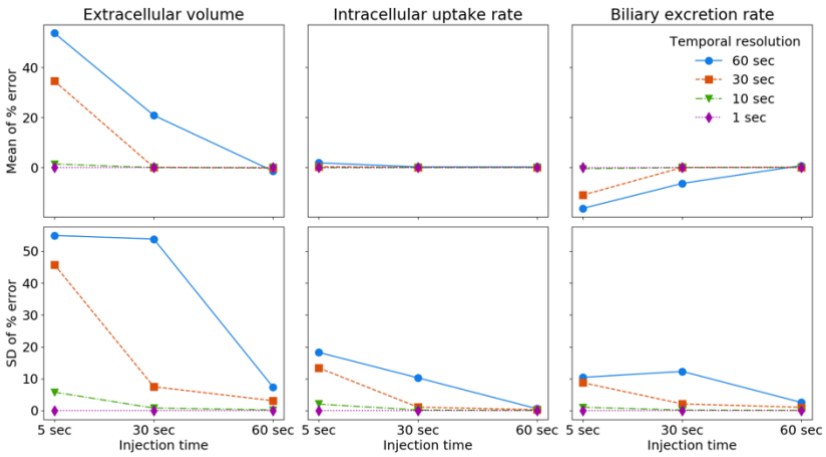
AIMS: This simulation study aims to demonstrate that slow infusion improves the precision of hepatocellular function measurements with DCE-MRI. In this preliminary analysis, we consider only the error caused by temporal under-sampling.

METHODS: Input functions $c_e(t)$ with injection times from 5 to 60 seconds at a fixed dose were simulated by shifting and adding scaled copies of a population input function [3]. Tissue concentration C(t) was simulated with a single-inlet, high flow two-compartment model:

$$C(t) = v_e c_e(t) + k_{ce} e^{\left(-\frac{k_{bc}}{1-v_e} t\right)} * c_e(t)$$

Parameter values were chosen for healthy liver [2]: extracellular volume fraction v_e = 0.2, intracellular uptake rate k_{ce} = 0.22 min^{-1}, biliary efflux rate k_{bc} = 0.017 min^{-1}. Pseudo-continuous signals were created for a steady-state SPGR sequence (TR = 2.74 ms, FA = 15°), and discretised at temporal resolutions from 1 to 60 seconds with a randomly chosen start time on the baseline. Parameters were fitted using the same model. As measures of accuracy and precision, we report mean and standard deviation of relative parameters errors after 20,000 simulations.

RESULTS: At any given injection time, the accuracy and precision in all parameters improve with higher temporal resolution. Conversely, at any given temporal resolution, accuracy and precision improve with longer injection times (figure). Under-sampling errors become negligible when the injection time roughly equals the temporal resolution.



CONCLUSION: Preliminary results suggest that DCE-MRI for the measurement of liver function should not be constrained by temporal resolution. The sequences can first be optimized for image quality, SNR, artefacts without considering temporal constraints, and then the injection time should be chosen at least as large as the temporal resolution.

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[1] Sourbron et al., *Radiology* 2012;263(3): 874-883. [2] Georgiou et al., *Invest Radiol* 2017;52: 111–119. [3] Parker et al., *MRM* 2006; 56:993–1000.