

# Measurement of Renal Extraction Fraction and Single Kidney Glomerular Filtration Rate Using MRI

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The single kidney glomerular filtration rate (skGFR), defined as the product of renal extraction fraction (EF) and renal plasma flow (q), provides the clearest indication of the functional state of the kidney. MR imaging offers a rapid, non-invasive measurement of skGFR based on EF, where EF is determined using Look-Locker (LL) T1 measurements of flowing blood in the renal artery and vein following MR contrast (Gd-DTPA) administration.

The LL T1 measurement sequence benefits from fresh spins provided by flow in the imaging slice during the relaxation recovery sampling interval (t). Under conditions of complete refreshment, no saturation of spins occurs and 900 read-out pulses can be used. We have developed both gradient echo (GE) and echo-planar imaging (EPI) versions of the LL sequence for measurement of EF in vitro (dialysis filter) and in vivo.

Under conditions of complete refreshment, GE and EPI LL determined dialysis filter Gd-DTPA EF within +10% and +8%, respectively, on the low ( $< 0.11$ ) and therefore more challenging end of the range expected in vivo (0.10 to 0.30).

In anticipation of slow flow in vivo, two methods were developed in vitro to extend LL T1 measurement accuracy to systems with incomplete refreshment: (i) An interleaved relaxation recovery sampling scheme (IRRS), and (ii) a post-processing method which discards non-equilibrium relaxation recovery samples from the T1 curve-fit. Both methods provided T1 measurement accuracy in non-refreshed systems comparable to refreshed systems. IRRS is expected to perform better in pulsatile systems, while the post-processing method allows over-sampling of the relaxation recovery.

The GE and EPI LL EF measurement techniques were validated in twelve unexcised swine kidneys. An inulin infusion method provided standard EF and skGFR. GE and EPI LL EF were not statistically different from inulin EF ( $p > 0.18$ ). Using MR imaging phase contrast renal blood flow measurements, no statistically significant differences were found between skGFR calculated using GE and EPI LL data, and single kidney inulin clearance ( $p > 0.27$ ). EPI and GE LL should provide complementary techniques for clinical assessment of renal function, and may allow resolution of renal hemodynamics following pharmaceutical manipulation.