

QUANTIFICATION AND REPRODUCIBILITY OF SINGLE KIDNEY FUNCTION USING DCE-MRI IN HEALTHY SUBJECTS

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PURPOSE. To evaluate the intra subject reproducibility and variance in estimation of renal perfusion and filtration rate assessed with repeated DCE-MRI examinations.

METHODS. Twenty healthy volunteers, mean age 25 years (SD=5) were scanned twice, 7 days apart, with identical 3D fast low angle shot (FLASH) sequences on our 1.5 T scanner (Siemens, Avanto). Instructions were given on fluid and food intake and all participants were asked to copy their regimen prior to each MRI-scan. Sequence parameters were: TR/TE: 2.36 ms/0.8 ms, FA: 20°, matrix: 192x192, voxel-size: 2.2x2.2x3 mm³, time resolution: 2.3 s, iPAT: 3, total acquisition time: 354 s. A dose of 0.025 mmol/kg Dotarem (Guerbet) was injected at 3 ml/s followed by a 25 ml saline flush. Sequences were run continuously with predefined breath-hold intervals, and free-breathing volumes were retrospectively discarded according to motion artefacts. A ROI-based two-compartment renal filtration model was applied on motion corrected breath-hold volumes using the analysis tool PMI¹ for quantification of blood flow (F_b), blood transit time (T_b), blood volume (V_b), tubular flow (F_T), tubular transit time (T_T), extraction fraction and GFR. Single kidney (SK) volumes and AIF were outlined semi-automatically using thresholds applied to perfusion maps. Intra-subject reproducibility was analyzed using mean coefficients of variations (CV), intra-class correlation coefficients (ICC) and Bland-Altman statistics.

RESULTS. The MRI-based mean renal function estimates were all in physiological normal ranges (Table 1), no statistical significant ($p > 0.05$) systematic differences between MR1 and MR2 estimates were found using a t-test. The group mean blood flow (F_b), extraction fraction and SK-volumes were reproduced with excellent test-retest agreement, other parameters showed slightly lower reproducibility (Table 1). The group mean squared coefficient of variation (CV²) between SK-parameters from MR1 and MR2 were for F_b: 17%, T_b: 18%, V_b: 14.5%, F_T: 15%, T_T: 24.5, extraction fraction: 23% and GFR: 14%. Mean differences in SK-GFR and renal blood flow (F_b) between MR1 and MR2 were 3.5 ml/min (95 % CI: -5.3-4.2) and 43.7 ml/100ml/min (95 % CI: 0.9-86.6), as illustrated in Bland-Altman plots (Fig.1, Fig.2).

DISCUSSION. Our study demonstrates SK-perfusion and filtration reproducibility (CV) in the range of 14-24.5%, where the vascular parameters F_b, T_b and V_b showed better test-retest agreement than the filtration parameters F_T, T_T and the extraction fraction. These results correspond well with previously reported reproducibilities of overall renal estimates using DCE-MRI 7-18%² and 25% for renal blood flow³. The within-subject variation may be accounted for partly by physiological day-to day variations related to state of hydration and nutrition⁴. Moreover, functional parameter estimates will also depend on methodological factors such as selection of arterial input function (AIF) and the presence of various artefacts⁵. The two outliers from the 95% CI in GFR-estimates (Fig.1) were both hampered by a combination of imperfect AIF and image artefacts.

CONCLUSION. Our results indicate that DCE-MRI can provide reliable and reproducible quantification of renal function in healthy volunteers presuming a high-quality MR-examination.

Table 1. Group means (standard deviations) and reproducibility of single kidney (SK) functional estimates between MR1 and MR2.

Parameter	MR1		MR2		ICC _{Left}	p	ICC _{Right}	p
	Left	Right	Left	Right				
	Mean (SD)	Mean (SD)	Mean (SD)	Mean				
SK-GFR (ml/ml)	47 (10)	50 (11)	47 (8)	54 (15)	0.6	0.018	0.6	0.027
SK region volume	161 (22)	158 (19)	162 (21)	162 (20)	0.9	< 0.001*	0.9	< 0.001*
Blood-flow (ml/100ml/min)	390 (121)	426 (138)	428 (88)	475 (108)	0.7	< 0.005*	0.8	< 0.001*
Blood MTT (sec)	4.3 (0.98)	4.6 (1.05)	4.2 (0.97)	4.2 (0.92)	0.6	0.022	0.4	0.119
Blood volume (ml/100ml)	26 (5)	31 (7)	29 (4)	32 (4)	0.6	0.038	0.7	0.006
Tubular flow (ml/100ml/min)	29 (6)	32 (6)	29 (5)	34 (8)	0.6	0.038	0.4	0.105
Tubular MTT (min)	2.4 (0.6)	2.5 (0.5)	2.8 (0.9)	2.8 (1.1)	0.5	0.053	0.3	0.194
Extraction fraction (%)	14.2 (5.5)	14.1 (5.7)	11.8 (2.6)	12.3 (3.0)	0.7	0.01	0.7	0.004*

ICC = intraclass correlation coefficient

Fig. 1 Bland-Altman plot showing agreement in total GFR-estimates obtained with MR1 and MR2

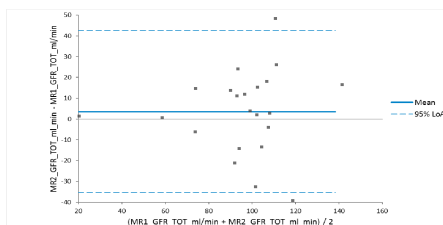
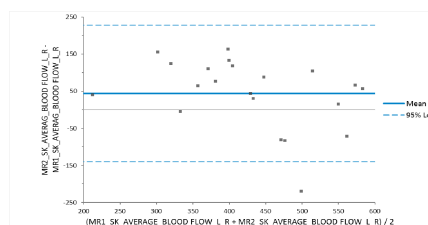


Fig. 2 Bland-Altman plot showing agreement in total renal blood flow (F_b) estimates obtained with MR1 and MR2



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