3D DYNAMIC CONTRAST-ENHANCED (DCE) MR RENOGRAPHY; EVALUATION OF IMAGE QUALITY AND ESTIMATION OF GFR COMPARING KWIC AND FLASH SEQUENCES

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PURPOSE. To evaluate the intra-individual variability in estimation of glomerular filtration rate (GFR) and to explore image quality characteristics of a radial k-space weighted image contrast (KWIC) sequence and a Cartesian fast low angle shot (FLASH) sequence.

METHODS. 10 healthy volunteers were examined with 7 days interval by both a 3D KWIC- and a FLASH-sequence on a 1.5 T scanner (Siemens, Avanto). MRI-parameters were for Kwic: TR/TE: 3.51/1.61 ms, FA: 10º, matrix: 160x160, voxel-size: 1.6x1.6x3 mm^3, time resolution: 2.5 sec, radial projection views: 148, total acq.time: 390 s.; and Flash: TR/TE: 2.41/0.87 ms, FA: 12º, matrix: 256x256, voxel-size: 1.7x1.7x3 mm^3, time resolution: 2.8 sec, iPAT: 3, total acq.time: 380sec. 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. Iohexol-clearance (GFR gold-standard) was measured on the third day after the first MRI-scan. Automated registration and segmentation techniques were used for kidney motion correction and for estimation of total kidney volumes. A variable flip angle (α= 5º and 22º) method was used to convert signal intensities to concentration time-courses. A ROI-based 2-compartment model described by Sourbron et al. [1] was used to locally estimate GFR. A visual grading characteristic (VGC) analysis of relevant image quality (IQ) criteria using a five-point grading scale (1-5) by four blinded observers was performed [2, 3]. To compare objective image quality characteristics, signal-to-noise (SNR) calculations were performed in registered datasets using the difference method [4].

RESULTS. The Flash gave more accurate and lower absolute differences in GFR-values than the Kwic compared to Iohexol-values as shown in Table 1. The automatically segmented whole kidney volumes from the Kwic were statistically significant ($P < 0.001$) smaller (mean 136 ± 41 ml) than from the Flash-images (mean 171 ± 33 ml). The visual image quality evaluation showed significant ($p < 0.005$) higher overall presence of artefacts in the Kwic (IQ score 3.5 ± 0.9) compared to the Flash (IQ score 4.4 ± 0.8). Differences in the presence of streaking artefacts (Flash: IQ score 4.5 ± 0.8, Kwic: 3.7±1.0) and of chemical shift at renal poles and contours (Flash: IQ score 3.9 ± 0.5, Kwic: 3.2± 0.6) were notified. Presence of motion artefacts were rated similar for Kwic and Flash, IQ score of 3.5 ± 0.6 and 3.2 ± 0.6, respectively. All SNRs measured in aorta and cortex were consistently higher in the Flash compared to Kwic as shown in Table 2.

DISCUSSION. The low number of projection views due to lack of parallel imaging in Kwic probably is the main reason for the impaired image quality from artefacts and reduced SNR. Our results indicate that the degree of impairment on image quality may influence the precision of the MR-derived GFR between sequences compared to Iohexol clearance. Both sequence-dependent sets of artefacts and SNR-levels might cause effects on different parts of the post-processing chain. Reduced image quality due to chemical shift and streaking artefacts in Kwic might explain some of the difficulties observed in the registration- and segmentation. Streaking artefacts could possibly also explain the large number of voxels for which GFR could not be estimated. The significant smaller whole-kidney volumes in Kwic compared to Flash, might be attributed to the chemical shift artefact partly cancelling signals around kidney. The difference in volume-estimation might correspondingly and partly explain the underestimation of the MR-derived GFR-values of the Kwic-sequences compared to Flash.

CONCLUSION. Using the same post-processing scheme to estimate MR-GFR, Flash was more accurate than Kwic when compared to Iohexol-GFR as gold standard.

REFERENCES. 1. Sourbron, S.P., et al. Invest Radiol, 2008. **43**(1): p. 40-8., 2. Bath, M. and L.G. Mansson, Br J Radiol, 2007. **80**(951): p. 169-76. 3. Hakansson, M., et al., Radiat Prot Dosimetry, 2010. **139**(1-3): p. 42-51., 4. Dietrich, O., et al., J Magn Reson Imaging, 2007. **26**(2): p. 375-85.

Table 1. A comparison of MR-derived total GFR and Iohexol-GFR

Subj.	Iohexol-clearance (ml/min)	MR_{GFR} (ml/min)	
		Flash	**Kwic**
1	128	92 (36)	95 (33)
2	97	91 (6)	33 (64)
3	104	84 (20)	37 (67)
4	124	128 (4)	116 (8)
5	91	118 (27)	107 (16)
6	128	121 (7)	98 (30)
7	103	154 (51)	94 (9)
8	109	75 (34)	35 (74)
9	135	139 (4)	102 (33)
10	89	77 (12)	68 (21)
Mean	**111 (16)**	**108 (20)**	**79 (36)**

Absolute difference values between MR-GFR and Iohexol-clearance in parenthesis.

Table 2. Comparison of the quantitative SNR-analysis of Flash and Kwic

	FLASH	KWIC	*P*
Baseline SNR cortex	5,56 ± 1,49	4,39 ± 1,2	0,141
Peak SNR cortex	11,85 ± 2,74	9,25 ± 4,68	0,169
Baseline SNR aorta	6,94 ± 3,09	5,94 ± 5,86	0,704
Peak SNR aorta	14,44 ± 3,22	11,45 ± 7,80	0,237
Enhancement ratio SNR in	1,43 ± 0,99	1,64 ± 1,34	0,759
Enhancement ratio SNR in	1,32 ± 0,96	1,19 ± 1,09	0,63
SI enhancement ratio in cortex	1,40 ± 0,25	0,99 ± 0,21	< 0,005 *
SI-enhancement ratio in aorta	1,51 ± 0,67	1,48 ± 0,62	0,92

* Statistically significant difference using a paired sample t-test. Estimates are averages and SD from ROIs drawn in cortex and distal aorta over all volunteers (n=10).