

MR-based semi-automated quantification of renal perfusion functional parameters with a two-compartment model - An interobserver analysis

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Background

Magnetic resonance imaging of the kidneys offers promising approaches for the detection and differentiation of renovascular and renoparenchymal diseases [1,2]. The combination of high temporal and spatial resolution renal MR exams allows to assess morphology and function. For the MR-based determination of renal perfusion and filtration parameters various theoretical models suffering from well known restrictions [3-4] were proposed. In our study, two-compartment model generalizing the so far defined goldstandard method, the Patlak model was used. As variability of functional parameters is a well known problem from other renal or myocardial functional studies [1,5] we aimed to assess the interobserver agreement in a semi-automated quantification approach of MR-renal perfusion and filtration parameters with this two compartment-model analysis.

Material and Methods

12 consecutive patients underwent renal perfusion measurements after intravenous injection of 7 ml Gd-BOPTA (Multihance®, Bracco) at 4 ml/s at 3. (Magnetom Tim Trio). The sequence parameters of the SR-TurboFLASH sequence were: TR / TE/ TI [ms] 203/0.90/101, flip angle 12°, bandwidth [Hz/Px] 9 matrix 192x134, FOV[mm³] 450x373, temporal resolution [slice/s] 5, parallel imaging GRAPPA 2.

Two independent observers placed two regions of interest (ROI) manually on the axial slice, one in the abdominal aorta to determine the arterial input function (AIF), and one at the tissue-air interface for retrospective triggering. The data were fitted on a pixel-by-pixel basis to the two-compartment model (Figure producing maps of the perfusion parameters F_p (plasma flow), T_p (plasma mean transit time) and of the tubular filtration parameters F_T (tubular flow) and (tubular mean transit time). A cortical ROI was segmented by selecting those pixels with plasma volume $V_p > 10\text{ml}/100\text{ml}$, and the model fit was repeated on ROI basis to produce the cortical averages (Figure 2).

Results

The average values (observer1 / observer2) were F_p (226.2 / 187.3 ml/100ml/min), T_p (9.0 / 9.1 s), F_T (23.5 / 20.8 ml/100ml/min), T_T (142.1 / 140.0 s). The correlation coefficients between both observers were 0.90 (F_p), 0.80 (T_p), 0.80 (F_T), 0.78 (T_T). Correlations of all values were significant ($p < 0.05$). A paired t-test yielded significant differences for F_p ($p = 0.004$).

Conclusion:

The results show a high degree of correlation and a good quantitative agreement between the parameters derived by both observers. The difference in flow parameters reflects a user-dependent bias in AIF selection, which may be minimized in future work by incorporating (semi)automated segmentation to identify the lumen of the aorta. In conclusion, the method shows promise as an observer-independent approach for the measurement of renal functional parameters with MRI.

References:

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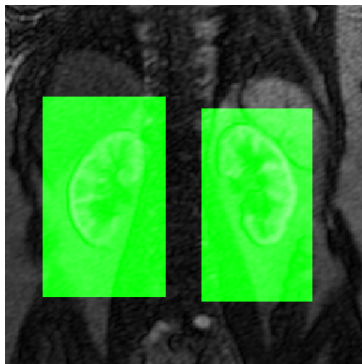


Figure 1 - For a reduction of calculation time kidneys were widely encompassed with two rectangular ROIs. Model fits were only performed for pixels within the ROIs.



Figure 2 - By selecting all pixels with $V_p > 10\text{ml}/100\text{ml}$ a cortex region was defined semi-automatically.