Characteristics and reproducibility of the arterial input function (AIF) derived from dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) studies and its effect on renal functional parameters

M. Cutajar[1,2], P. S. Tofts[2], I. A. Mendichovszky[3], and I. Gordon[1]

[1]Radiology and Physics, UCL Institute of Child Health, London, United Kingdom, [2]Brighton and Sussex Medical School, Brighton, United Kingdom, [3]Imaging Science and Biomedical Engineering, University of Manchester, Manchester, United Kingdom

Purpose: The aim of this study was to investigate parameters of the aortic input function (AIF) in dynamic contrast-enhanced (DCE) magnetic resonance imaging (MRI) of the kidney and its effect on renal functional parameters (perfusion and glomerular filtration rate) calculated using a two-compartment model analysis.[1] Inter-observer agreement, effect of size of region of interest (ROI) in the aorta and reproducibility in DCE-MRI studies have been evaluated.

Methods: Ten healthy volunteers underwent two identical DCE-MRI studies under similar physiological conditions. Oblique-coronal DCE-MRI data volumes were acquired on a 1.5T Siemens Avanto scanner with a 3D-FLASH pulse-sequence (TE/TR = 0.53/1.63 ms, flip angle = 17º, acquisition matrix = 128 × 104 voxels, strong fat saturation, PAT factor = 2 (GRAPPA) and 400 × 325 mm FOV). Each dynamic dataset consisted of 18 slices of 7.5 mm thickness (no gap) and an in-plane resolution of 3.1 × 3.1 mm, acquired every 2.5 s for > 5 minutes. During the MR scan a dose of 0.05 mmol (0.1 mL) kg^{-1} body weight of dimeglumine gadopentetate (Magnevist) was injected intravenously (2 mL s^{-1} injection rate), followed by a 15 mL saline flush at the same rate, using a MR-compatible automated injector (Spectris).

Two independent observers drew two ROIs on each study, one small and the other large (AIF 1, the small ROI was 12 voxels (3 × 4) and AIF 2, the large ROI was 30 voxels (3 × 10)): how, where and when to draw the ROI was agreed prior to starting the analysis. The average signal in each ROI was plotted as the signal intensity against time. The parameters of the AIF plot assessed were the maximum height of AIF, the full width at half maximum and area under different sections of the AIF plot. Each AIF was then used in conjunction with a parenchymal ROI to generate renal functional parameters.[1] Statistical methods were used to quantify the discrepancies between (a) the two observers, (b) the two AIF ROI sizes, (c) the two studies performed on different days and finally (d) the effect (b) and (c) have on renal functional parameters.

Results and Conclusion: Paired *t*-tests for inter-observer comparison on the pooled 10 DCE-MRI studies, showed good correlations (correlation coefficients > 0.85) with no significant differences (*p*-values > 0.82) when comparing the AIF plot characteristics. Thus the results were operator independent. The size of the aortic ROIs significantly affected all measured parameters of the AIF (*p*-values < 0.039). However, correlation coefficients when comparing AIF 1 and AIF 2 were high for all evaluated AIF parameters (correlation coefficients > 0.88), indicating a similar shape and temporal dynamic of the passage of the contrast agent through the aorta. When comparing the intra-individual DCE-MRI studies for each volunteer all AIF parameters had *p*-values > 0.22 and correlation coefficients < 0.82, with the exception of the full width at half maximum, which had a correlation coefficient of 0.96, revealing a wide standard error of the estimate in the individual volunteer. In addition, analysis of the whole population shows a large variation in AIF parameters even when body proportions were taken into account. This implies that a universal AIF, as being suggested by several MRI machine manufacturers, is not recommended.

Results of repeatability and reproducibility of both renal perfusion and glomerular filtration rate showed that different size AIF ROIs significantly affect (*p*-values < 0.011) the functional values obtained. *p*-values > 0.22 were obtained when paired *t*-tests were performed to compare studies undergone by the same person on different days. This implies that, while the functional values obtained for the same person imaged on different days are reproducible, the AIF ROI selection is crucial.

References: [1] Tofts P et al. A simple two-compartment model that describes Dynamic Contrast-Enhanced MRI signal in the kidney. ISMRM 16th Scientific Meeting & Exhibition abstract number 454, Toronto, 2008.