DCE MRI based perfusion parameters in renal transplants: influence of the choice of the arterial input function.

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Purpose: Renal MRI has the potential to provide anatomical and functional information [1-5]. The feasibility of voxel-by-voxel perfusion mapping based on deconvolved DCE renal data has already been shown by our group [5], but renal blood flow values with this technique are lower than those found in the literature [6]. Possible causes of perfusion underestimation are dispersion (the magnitude of this error is significant in stroke [7]) and partial volume effects from small arterial input functions (AIFs). This study tries to estimate the influence of dispersion and partial volume effects by comparing the perfusion results in renal transplant data deconvolved with two different arterial input functions. In transplants the smaller lobar artery near to the transplant as well as the larger iliac artery further away can be imaged in an axial slice.

Methods:

Imaging was performed on 5 renal transplant patients in the supine position at 1.5T. All experiments were approved by the local ethical board. Single slice IR-prepared Flash (TR 4.4 ms/ TE 2.2 ms/ TI 180 ms/ FA 50°/ matrix 128*256/ FOV 450-490 mm/ dynamics 400, temporal resolution 0.3 s) was performed during the injection of 10 ml Gd-DTPA injected by power injector at 2ml/s. Post-processing was performed offline on a personal computer using the software PMI 0.2 written in-house in IDL (Research Systems, Boulder, CO). Signals were calibrated by using a test tube containing 2mM Gadolinium in saline solution placed in the FOV during the measurement. Signals were converted to tracer concentrations and deconvolved with an AIF with an optimized deconvolution procedure [8]. A simple inflow correction was applied. Parametric maps of renal blood flow (RBF), renal volume of distribution (RVD) and mean transit time (MTT) were calculated as the maximum of the impulse response function (IRF), the time integral of the IRF and the ratio RVD/ RBF. The tissue time concentrations were deconvolved twice: once with an AIF (pixel ROI) selected manually in a small lobar artery very near to the transplant (resulting in RBF_{lob}, RVD_{lob} and MTT_{lob}) and once with an AIF drawn as a ROI in the much larger iliac artery further away from the target organ (leading to RBF_{il}, RVD_{il} and MTT_{il}).Whole cortical measures of perfusion were calculated of transplant cortex ROIs, drawn on the RBF images. RBF_{lob}, RVD_{lob} and MTT_{lob} were compared to RBF_{il}, RVD_{il} and MTT_{il}, respectively.

Results:

The average results of RBF, RVD and MTT for the two AIF selections are given in figure 1. Average RBF_{lob}, RVD_{lob} and MTT_{lob} for the 5 transplants were 4.6 ml/min/ml with SD 1.7 ml/min/ml , 1.3 ml/ml with SD 0.7 ml/ml and 21 s with SD 13 s. Average RBF_{il}, RVD_{il} and MTT_{il} were 2.5 ml/min/ml SD 1.0 ml/min/ml, 1.0 ml/ml SD 0.4 ml/ml and 27 s SD 14 s. RBF_{lob} is higher than RBF_{il} in each transplant. RVD_{lob} is higher than RVD_{il}, with one exception (Pat2) where the difference is small. MTT_{lob} is always shorter than MTT_{il}.

Conclusion:

RVD_{lob} values are higher than RVD_{il}, which cannot be explained by bolus dispersion but is consistent with AIF underestimations due to partial volume effects in the smaller artery. In MTT partial volume effects play no role, so that the trend in the data ($MTT_{lob} < MTT_{il}$) can be attributed to the effect of bolus dispersion. RBF is influenced by both effects, but the results show that partial volume effects dominate over those due to dispersion.

We conclude that for quantitative DCE MRI based perfusion parameters in renal transplants the choice of the arterial input function in a larger -but more distant- artery such as the aorta or the iliac artery is the more accurate approach, since dispersion errors are smaller than partial volume effects caused by AIF selection in a small proximate artery.

References:

[1] Hermoye L. et al (2004) MRM 51: 1017- 1025
[2] Schoenberg S. et al (2003) MRM 49:288-298
[3] Aumann S. et al (2003) MRM 49: 276- 287
[4] Pedersen M. et al (2004) Proc. ISMRM 11:879
[5] Dujardin M. et al (2005) MRM 54(4):841-9
[6] Hierholzer K (1999) Physiologie des Menschen:737-776
[7] Wu O. et al. (2003) MRM 50:164-74
[8] Sourbron S. et al (2007) PMB 52:429-447

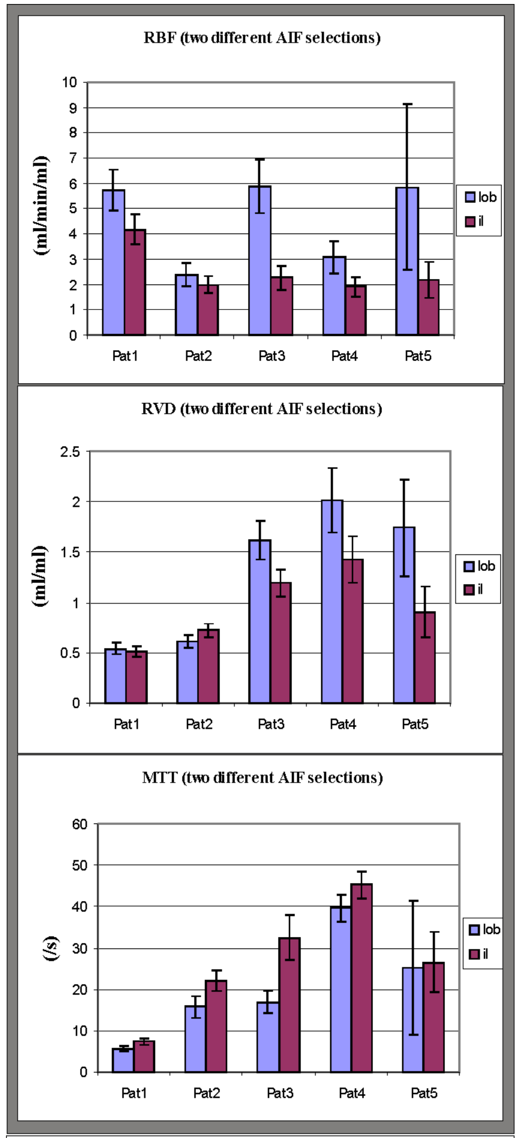

Figure 1: average results of RBF, RVD and MTT with two different AIF selections (lob = lobar small artery near the transplant , il = larger more distant iliac artery)