Comparison of Gd-DTPA and Gd-BOPTA for studying renal perfusion and filtration

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Introduction: Gadobenate-dimeglumine (Gd-BOPTA) is a potential alternative for gadopentetate-dimeglumine (Gd-DTPA) to measure renal perfusion and filtration with MR-Renography, but protein-binding may cause a systematic error in glomerular filtration rate (GFR) (1). The purpose of this study was to measure the influence of serum protein interaction of Gd-BOPTA on perfusion and filtration parameters

Material and Methods: The 2-compartment filtration model for Gd-DTPA (2) was generalized to allow for protein binding. Eight healthy Danish-Landrace-pigs were examined in general anaesthesia at 1.5T with a saturation-recovery TurboFLASH sequence (1 axial and 2 coronal slices; temporal resolution 1s; TR 194ms; TE 0.96ms; IR 9ms; slice thickness 8mm). A double-bolus protocol with Gd-DTPA as first bolus followed by Gd-BOPTA as second bolus or vice versa (group I; Gd-DTPA/Gd-BOPTA n = 4 vs. group II Gd-BOPTA/Gd-DTPA n = 4) was performed. An arterial input function (AIF) was defined manually in the aorta and cortical regions-of-interest were defined semi-automatically in left- and right kidneys using thresholds on plasma volume. Data were fitted to the generalized 2-compartment filtration model, producing split renal plasma-flow (FP) and -volume (VP), tubular flow (FT) or glomerular-filtration-rate (GFR) and tubular transit time (TT). Urine protein levels were obtained. Gd-DTPA and Gd-BOPTA values were compared with the Wilcoxon-signed-rank-test. Differences between both groups were assessed with the Wilcoxon-rank-sum-test.

Results: The pigs demonstrated a weak proteinuria of 0.27 ± 0.08g/l. There were no significant differences between group I (Gd-DTPA then Gd-BOPTA) and group II (Gd-BOPTA) for any of the parameters. The AIF measured with Gd-BOPTA showed a significantly higher maximal enhancement (162.8 ± 36.9 AU), compared to the AIF derived from Gd-DTPA (145±29.8 AU) ($p<0.01$) (Figure 1). The perfusion parameters plasma flow and plasma volume did not show significant differences between Gd-DTPA and Gd-BOPTA. Tubular flow (= glomerular filtration rate / tissue volume) derived from Gd-BOPTA was significantly lower (p=8.6 x 10-10) than derived from Gd-DTPA. The mean difference was approximately 33.2% (range 20.4% - 48.3%). There were no significant differences for tubular transit time derived from Gd-DTPA or Gd-BOPTA (Table 1 and Figure 2).

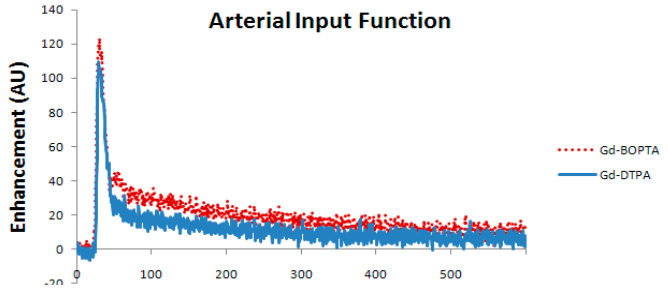

Figure 1: Typical AIF of Gd-BOPTA (red) and Gd-DTPA (blue)

Parameter	Gd-DTPA	Gd-BOPTA	Difference %
Plasma flow (ml/100ml/min)	250.8 ± 54.9	243.9 ± 65.7	2.2 ± 18.5
Plasma Volume (ml/100ml)	20.5 ± 4.1	20.9 ± 4.8	-1.7 ± 7.8
Tubular flow (ml/100ml/min)	27.8 ± 3.0	18.6 ± 1.9	33.3 ± 7.2
Tubular Transit Time (sec)	118.9 ± 14.8	115.0 ± 15.4	3.1 ± 7.2

Table 1: Results of the dual agent protocol

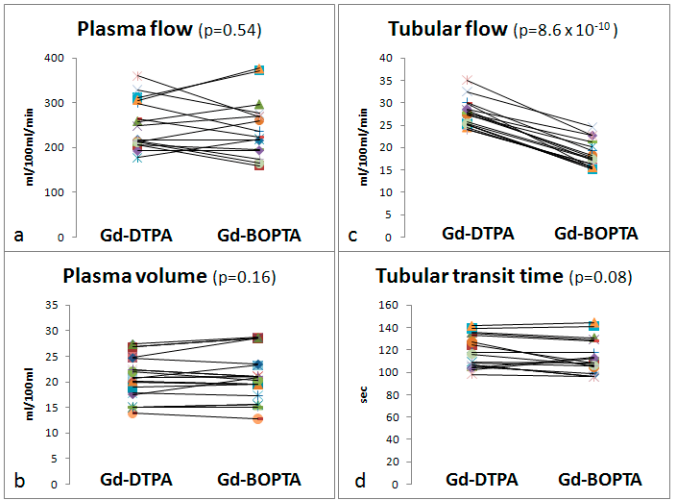

Figure 2: Comparison between Gd-DTPA and Gd-BOPTA

Conclusion: Theory and experiments agree that perfusion parameters calculated with Gd-DTPA and Gd-BOPTA are comparable, whereas GFR is systematically underestimated with Gd-BOPTA. The measured underestimation (33%) is weaker than predicted by the theory (40%), but this is consistent with the observed weak proteinuria in the pigs. The results demonstrate that GFR cannot be measured with protein-bound contrast agents, but the dual-agent protocol proposed in this study may produce new functional indices related to protein leakage across the glomerular membrane.

References:

[1] J. Pintaske, et al. *Invest Radiol*. 2006; 41: 213--221.
[2] S. Sourbron, et al. *Invest Radiol.* 2008; 43: 40--48.