Prediction and assessment of response to renal artery revascularization with dynamic contrast-enhanced MRI: a pilot study

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MOTIVATION: Revascularization in atherosclerotic renal artery disease is not broadly supported [1], due to the associated risks and the fact that only a minority of patients derive net benefit [2]. There is a need for identifying the patients that are likely to benefit [3], but current prognostic indices are limited by insufficient characterization of stenosis severity and failure to detect intra-renal parenchymal injury distal to the stenosis [4].

PURPOSE: To assess the potential of dynamic contrast-enhanced MRI (DCE-MRI) measurements of renal function and perfusion to predict and evaluate functional outcome after renal artery revascularization in humans.

MATERIALS AND METHODS: 16 patients with renal artery stenosis underwent DCE-MRI and radioisotope measurement of single-kidney glomerular filtration rate (SK-GFR) at baseline, and 4 months after revascularization. Quantitative analysis of DCE-MRI [5] produced a measurement of SK-GFR as well, and additional measures of perfusion (blood flow, blood volume) and function (extraction fraction, tubular MTT, functional volume). SK-GFR values of DCE-MRI and radio-isotopes of all kidneys (n=64) were compared by Bland-Altman analysis. Stented kidneys (n=23) were divided into three response groups on the basis of changes in isotope SK-GFR: improve (n=5), stable (n=14), deteriorate (n=4). The predictive value of DCE-MRI was assessed by comparing the pre-procedure values between these response groups. The potential of DCE-MRI for response monitoring was assessed by comparing pre- and post-procedure values within each response group. Statistical significance was defined at $p<0.05$.

Table 1. Pre-procedure	Deteriorate	Stable	Improve
Blood Flow(ml/min/100ml)	219 ± 62	208 ± 97	209 ± 122
Blood Volume (ml/100ml)	35 ± 4.2	40 ± 10	44 ± 8.8
Extraction Fraction (%)	9.5 ± 4.3	9.5 ± 3.3*	6.1 ± 2.7
Tubular MTT (min)	2.3 ± 0.8	2.8 ± 0.6	3.9 ± 1.5
Functional Volume (ml)	174 ± 51	196 ± 96	143 ± 57
(DCE-MRI) SK-GFR (ml/min)	22 ± 15	21 ± 15	11 ± 8.3
(Isotope) SK-GFR (ml/min)	24 ± 17	24 ± 15*	12 ± 8.9

Table 2. Post-procedure	Deteriorate	Stable	Improve
Blood Flow (ml/min/100ml)	226 ± 42	228 ± 106	285 ±115
Blood Volume (ml/100ml)	55 ± 6.8*	43 ± 10	56 ± 17
Extraction Fraction (%)	7.1 ± 4.4*	8.7 ± 1.9	5.5 ± 2.4
Tubular MTT (min)	2.7 ± 0.8*	3.1 ± 1.3	2.8 ± 0.5
Functional Volume (ml)	160 ± 52*	185 ± 83	193 ± 47*
(DCE-MRI) SK-GFR (ml/min)	18 ± 16	20 ± 13	15 ± 6.2
(Isotope) SK-GFR (ml/min)	18 ± 13	23 ± 15	17 ± 12

RESULTS: There was no significant difference between SK-GFR values from DCE-MRI and isotopes, and both showed the same trends in all groups. The mean difference was -1.3ml/min (95% confidence interval: -15 to +12ml/min). **Table 1** shows mean ± SD *before* intervention (* indicates significant difference with improved group): kidneys that improved had lower extraction fraction; higher blood volume and lower SK-GFR were associated with better outcome, but these trends were not significant. **Table 2** shows mean ± SD *after* intervention (* indicates significant difference with preprocedure values): blood flow and -volume were increased, but only the latter showed significance; improved kidneys had increased functional volume; deteriorated kidneys had reduced functional volume and extraction fraction.

DISCUSSION/CONCLUSION: DCE-MRI has the potential to replace radioisotope measurement of SK-GFR for planning and follow-up of renal artery revascularisation, and may improve patient selection through the additional information on vascularity. Specifically, this pilot study suggests that well-vascularised kidneys with low extraction fractions are most likely to benefit. The result agrees with preclinical studies showing that a preserved microvasculature is associated with better outcome [6]. Future studies should aim at increasing statistical power by including more kidneys that show strong changes under therapy.

REFRENCES: [1] Wheatley et al (2009) *N Engl J Med*; 361 (20): 1953--62. **[2]** Bax et al (2009) *Ann Intern Med,* 150 (12): 840–8. **[3]** Cheung et al (2009) *Nephrol Dialy Transpl,* 25: 1133--40. **[4]** White and Olin (2009) *Nat Clin Pract Card,* 6: 176–90. **[5]** Sourbron et al (2008) *Invest Radiol,* 43: 40–8. **[6]** Chade and Kelsen (2010) *Circ Cardiovasc Interv,* 3: 376–83.