The effect of renal denervation on renal oxygenation as measured on BOLD MRI

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Purpose Renal denervation (RD) is a promising new therapy for resistant hypertension.[1,2] The mechanism of action is proposed to be a decrease in sympathetic activity, resulting in altered sodium handling by the kidneys and a decrease in peripheral vascular resistance.[3] As a consequence, one can hypothesize that renal blood flow and oxygenation will increase. In the context of an on-going explorative study on the influence of RD on renal parameters, blood oxygen level dependent (BOLD) MRI was performed to obtain insight in changes in renal oxygenation after RD.

Method 38 patients (20 female, mean age 57) with a systolic BP ≥160mmHg despite the use of ≥3 antihypertensive drugs or the inability to follow a stable drug regimen due to unacceptable side-effects, meeting in- and exclusion criteria for treatment with RD were included in this study. BOLD MRI (20 patients on 3.0T and 18 on 1.5T) was performed before and 12 months after RD. Since most drugs influence BOLD MRI, use of anti-hypertensive medication was stopped before MRI when considered safe. Coronal (3 slices) and transversal (6 slices) T_2*-weighted scans with 20 different echo times (first echo 4.6ms, step size 4.6ms) were performed with voxel size 1.3x11.27x1.3 mm^3 (1.5T) or 1.3x12.0x1.3 mm^3 (3.0T) (fig 1). The R_2* map was calculated from the T_2* data by fitting an exponential curve to the echo times. MRIs were analysed using the compartmental method proposed by Ebrahimi et al.[4] The histogram of the R_2* map was calculated and fitted to a Gaussian function (cortex) and a gamma function (medulla) (fig 2).To identify changes in hypoxic regions of the kidney, the third quartile of the R_2* histogram was also taken into account. To objectively differentiate between medulla, collecting system and vessels, a semi-automatic filter was applied to the R_2* maps. High intensity voxels, representing collecting system, and low intensity voxels, representing blood vessels, were excluded, as well as the four adjacent voxels (fig 2). To assure reproducibility of succeeding MRIs, ROIs of the psoas muscle were used in coronal slices, assuming that RD does not influence muscle oxygenation. Wilcoxon signed rank test was used for paired sample analysis. A two sided P value of <0.05 was considered to be statistically significant. Data from 1.5T and 3.0T were analyzed separately.

Results Four examinations were excluded completely and in four scans only coronal or transversal images were excluded, mostly because of motion artifacts. Both in kidney and muscle no statistically significant changes in oxygenation occurred after RD (table 1, fig 3). As expected, cortical and medullary values measured at 3.0T were increased with respect to values measured on 1.5T by a factor of 1.4.

Discussion and Conclusion To the best of our knowledge, this is the first study investigating the effect of RD on BOLD MRI. Objective analysis of BOLD MRIs was assured by application of the compartmental method in combination with the filter. RD does not seem to influence renal oxygenation.

Table 1: *R_2* values of kidney (medulla, cortex, third quartile) and muscle before and after RD.*

Table 1		R_2* baseline (Hz)	R_2* 12 months follow-up (Hz)	p-value
1.5T	Median medulla cor/trans (IQR)	**18.6/18.4** (17.2-19.5/17.0-20.5)	**18.4/19.1** (17.5-19.5/17.7-19.8)	0.61/0.94
	Mean cortex cor/trans (IQR)	**12.4/12.5** (11.3-12.9/11.6-13.4)	**12.4/12.7** (11.6-13.3/12.2-13.1)	0.84/0.42
	Third quartile cor/trans (IQR)	**16.5/17.1** (15.0-19.3/15.7-18.6)	**16.2/18.0** (15.2-18.6/15.0-19.7)	0.72/0.52
	Muscle (IQR)	**36.0** (34.4-37.0)	**35.1** (34.0-36.0)	0.19
3.0T	Mean medulla cor/trans (IQR)	**26.3/26.5** (25.4-27.5/24.8-27.8)	**26.2/25.8** (24.6-28.1/25.1-27.8)	0.64/0.50
	Mean cortex cor/trans (IQR)	**17.7/17.8** (17.3-19.2/17.4-18.7)	**17.9/17.5** (17.1-19.2/16.9-18.4)	0.73/0.16
	Third quartile cor/trans (IQR)	**28.1/29.4** (26.7-31.1/27.4-30.6)	**28.9/28.7** (25.1-30.0/26.3-30.6)	0.43/0.37
	Muscle (IQR)	**38.8** (36.5-39.5)	**37.7** (35.8-38.8)	0.46

Fig 1 (left): *T_2* image (TE=13.8ms) showing kidney and muscle. ROIs are depicted in red.*

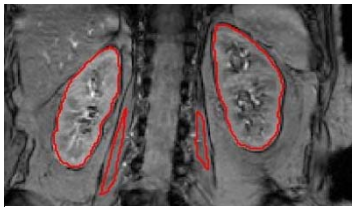


Fig 2 (middle): *According to the compartmental method[4] cortex is fitted to a Gaussian (blue) function and medulla to a gamma (pink) function. The sum (red) fits the histogram of the R_2* map shown in the figure. The collecting system is excluded by the filter (shown in red).*

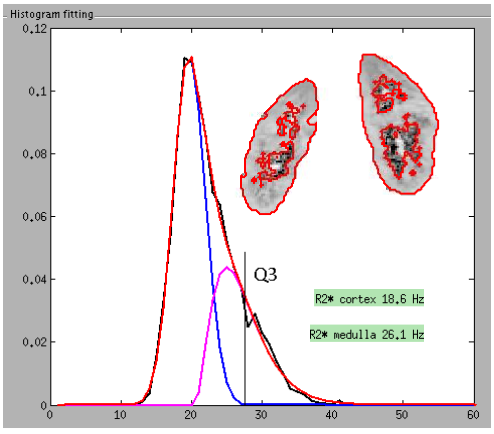
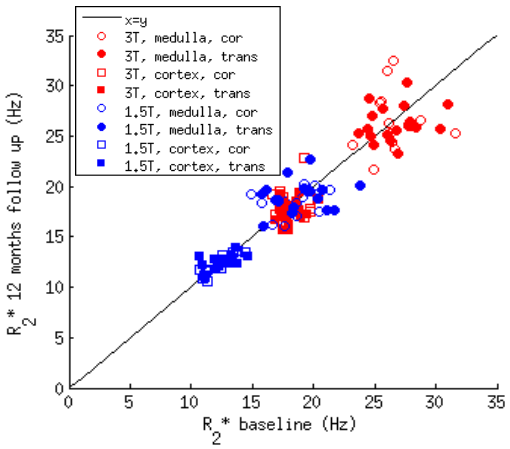


Fig 3 (right): *Scatter plot of the R_2* values (cortex and medulla) before and after RD.*



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