

Quantitative BOLD response of the renal medulla to hyperoxic challenge at 1.5T and 3.0T

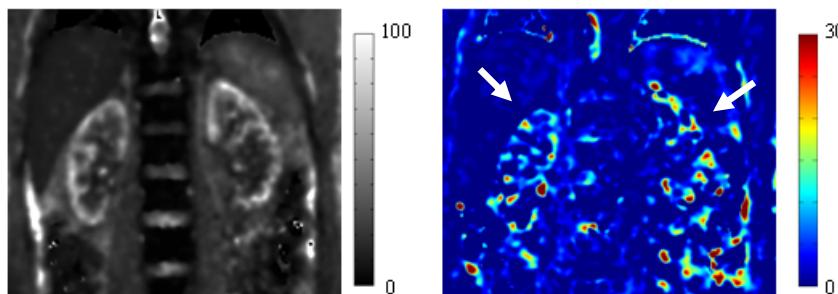
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Purpose: Whereas renal cortex is well perfused and supplied with oxygen, the renal medulla is an area of constant hypoxia and, thus, prone to hypoxic injury. Details of regulation mechanisms and the role of renal medullary hypoxia in the development of different types of renal diseases are not well understood. The aim of this study was to evaluate, whether attempted modifications of renal hypoxia by inhalation of oxygen or carbogen (95% O₂, 5% CO₂) can be monitored and quantified with a measurement of the induced change in T2* relaxation time.

Material and Methods: Eight healthy young volunteers (age between 31 and 38 years) participated in the study, which was approved by the local Ethics committee. All participants underwent MR imaging in a 1.5T and a 3.0T whole body MR scanner. Images from a coronal slightly oblique oriented plane were acquired three times with a 2D multi-echo gradient-echo sequence (15 echoes, TE₁ = 7ms, ΔTE = 5 ms, TR = 160 ms, matrix size 256 x 256, in-plane resolution 1.5 x 1.5 mm, slice thickness = 5 mm, parallel imaging SENSE 2, flip 40°) during breath-hold, after 4 minutes inhalation of room air, pure oxygen, or carbogen, respectively. Breathing gases were supplied with a partial non-rebreathing mask at a flow rate of 8 l/min. Parametrical maps of T2* relaxation times were computed by mono-exponential fitting on a pixel-by-pixel basis. Region-of-Interest evaluations were performed in representative anatomical positions of the renal medulla, the renal cortex, the liver, and the spleen. For visualization of changes, T2* maps acquired while breathing in different gases were subtracted.

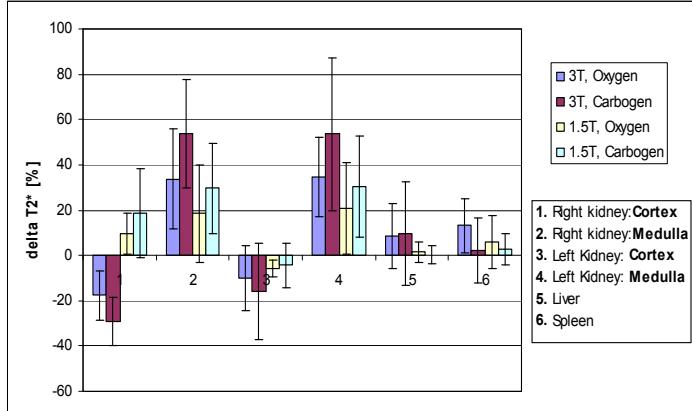
Results: In all volunteers, parametrical T2* maps could be obtained in good image quality.



Parametrical T2* map computed from a data set during room air breathing (at 3T), units of ms.

Subtraction of parametrical T2* maps acquired under oxygen breathing and room air breathing (ΔT2*), unit of ms.

In the subtraction maps, the strongest differences between room air and oxygen/ carbogen breathing were seen in the renal medulla with an increase of 30-35% for oxygen breathing (p<0.01) and of 50-55% for carbogen breathing (p<0.01) at 3T. Differences were approx. halve as large at 1.5T. A slight reduction of the T2* time was found for the renal cortex (~10-20%) at 3T. No significant T2* differences were detected for relaxation of liver or spleen magnetization. An overview is given in the diagram on the lower left side.



Discussion: Possibly due to its hypoxic condition, the strongest effects of oxygen and carbogen inhalation were observed in the renal medulla. This may be rationalized with a relatively higher uptake of oxygen and a concomittant decrease of deoxyhemoglobin and, therefore, a prolongation of T2* relaxation time. The observed effect was stronger for carbogen than for oxygen breathing, possibly due to vasodilation. The slight decrease in T2* of the renal cortex may likely be due to changes in perfusion, which should be further investigated.

Conclusion: Renal medullary T2* relaxation times increase after inhalation of either carbogen or oxygen. This may be useful for quantification of renal hypoxia in patients with kidney diseases and provide new insights into pathophysiology.