Using BOLD-MRI to assess oxygenation status in human renal transplantation

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Introduction

Renal transplantation is the treatment of choice for end-stage renal diseases because both survival and quality of life are improved. However, graft dysfunction is a common occurrence during the first weeks following renal transplantation [1]. Therefore, a reproducible non-invasive technique for the detection of organ dysfunction would be a valuable diagnostic tool in kidney transplantation. The aim of this study was to assess the efficacy of blood oxygen-level dependent imaging (BOLD-MRI) [2] in detecting graft abnormalities and to determine "normal ranges" for allografts in comparison with native healthy kidney.

Methods

This study was performed on 11 subjects (8 men, 3 women; mean age: 48.6 ± 14.6 years) with transplanted kidneys with stable renal function (according to serum creatinine levels), and compared to 11 healthy subjects (6 men, 5 women; mean age: 42.6 ± 12.1 years). Labor values including serum creatinine were obtained from all patients immediately after the MR examination. BOLD-MRI measurements were performed on a 1.5T MR system (SONATA, Siemens, Germany) using a body coil for transmission and a phased array surface coil for reception. A modified Multi Echo Data Image Combination sequence (TR: 65 ms, TE: 6-52.31ms, flip angle: 30°) was used to acquire 12 T_2*-weighted images within a single breath-hold. Four to 5 coronal slices were acquired to cover the kidney. In addition, diffusion-weighted imaging (DWI) was performed. For detailed results of the DWI measurements see [3]. For BOLD processing, 6 ROIs were drawn for each slice, in upper, medium and lower poles of medulla and cortex. R_2* indices were calculated [4] and the data were combined to obtain a single mean value. A unpaired Student's t-test was employed for statistical analysis of the results.

Results

Visual inspection of the images showed poorer cortico-medullary differentiation than was previously seen for native kidneys (Fig. 1) [4,5]. Mean R_2* values in medulla ranged from 10.52 ± 0.31 to 16.25 ± 1.94 s^{-1} and from 10.38 ± 1.18 to 12.06 ± 2.83 s^{-1} in cortex. The cortex values in transplanted kidneys were slightly lower ($p = 0.04$) than in healthy [5] subjects (Fig. 2). In addition, medullary values were markedly lower than those of healthy subjects ($p < 0.001$), and R_2* was even lower in medulla than in cortex for three subjects (Fig. 2). The variance of the R_2* values in allografts was slightly lower than in control kidneys. No significant correlation between R_2* values and serum creatinine levels was found. A significant correlation ($r = 0.68$, $p < 0.001$) was detected between cortical R_2* values and hemoglobin concentration, but the results need to be further confirmed. We found a highly significant negative correlation between ADC values (DWI) and medullary R_2* indices ($r = -0.81$, $p < 0.003$).

Fig. 1: R_2* map of a renal allograft

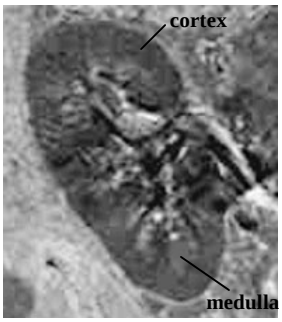
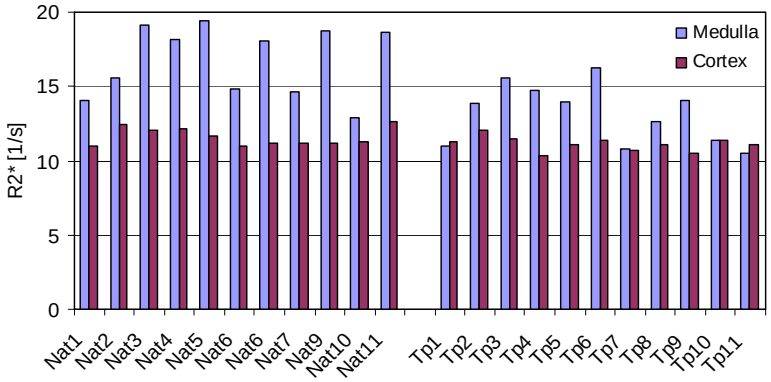


Fig. 2: Comparison of R_2* values between native (Nat) [5] and transplanted (Tp) kidneys



Discussion/Conclusion

BOLD measurements were efficient to detect graft differences to normal kidneys by showing lower R_2* values in medulla compared to cortex. Yet, increased pO_2 in medulla has been associated to kidney rejection [6]. The results evidenced a significant ($p < 0.001$) lower "normal range" of R_2* values in medulla of well functioning allograft in comparison with native kidney. One reason for this may be the influence of immunosuppressive drugs [4] systematically administrated after transplantation. The negative correlation between ADC values and R_2* values in medulla suggest that reduced oxygenation is accompanied by decreased diffusion.

References

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