

FUNCTIONAL EVALUATION OF ACUTE ISCHEMIA-REPERFUSION INJURY USING DIFFUSION-WEIGHTED IMAGING

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Purpose:

Ischemia/reperfusion (IR) injury is considered the leading cause of acute renal failure (ARF), and frequently occurs in clinic, such as renal transplantation [1,2,3]. MR diffusion-weighted imaging (DWI) is currently the noninvasive method available to assess molecular diffusion and microcirculation of blood in tissue in vivo. DWI yields the apparent diffusion coefficient (ADC) which provides functional status of the IR injured kidney [4]. The purpose of this study was to verify the possibility of DWI to evaluate the functional alterations in kidneys following normothermic IR injury in a rabbit model.

Materials and Methods :

MRI: Six healthy male New Zealand White rabbits were randomly allocated to two groups, and examined in the unilateral renal IR injury experiments after anesthetization. Artery of the left kidney was ligated with silk line for 20 minutes for group1 (G20, n=3) and 40 minutes for group2 (G40, n=3). MR scans were performed on 1.5T MR scanner (GE Medical Systems, Milwaukee, WI, USA). Baseline1 was scanned before operation and baseline2 after operation, and seven reperfusion points were scanned per 15 minutes after release of ligation. One ligation point was scanned for G20 and three ligation points were scanned for G40. The right kidneys were regarded as the control group. DWI was performed using a spin-echo type sequence with an echo-planar imaging readout (SE-EPI). The imaging parameters were: TR/TE = 2300ms/70ms, flip angle = 90°, b value = 800s/mm², FOV = 10mm, nex = 2, matrix was 128x128, slice thickness = 5mm and four axial slices were obtained. The ADC values were constructed with FUNCTOOL on GE ADW 4.2 workstation using the formula: $ADC = -\ln(S/S_0)/(b-b_0)$, where S and S₀ are signal intensities in regions of interest: cortex (CO), outer medulla (OM) and inner medulla (IM), shown in Fig. 1, b₀=0 seconds/mm² and b=800 seconds/mm².

Results:

For the IR injured kidney, ADC values of the cortex after ischemia was significantly lower than baselines: $0.301 \times 10^{-3} \pm 0.72 \times 10^{-4}$ vs. $0.725 \times 10^{-3} \pm 0.94 \times 10^{-4}$ (baseline1) and $0.587 \times 10^{-3} \pm 0.22 \times 10^{-3}$ (baseline2), p<0.01 for G40; $0.278 \times 10^{-3} \pm 0.65 \times 10^{-4}$ vs. $0.514 \times 10^{-3} \pm 0.11 \times 10^{-3}$ (baseline1) and $0.468 \times 10^{-3} \pm 0.31 \times 10^{-4}$ (baseline2), p<0.05 for G20. Significant lower values of cortex were also found for the other two ligation points in G40. For the outer medulla, immediately decrease was found after 40min ligation and maintained a low level during ligation period (p<0.05). However, no statistical differences were found in outer medulla (p=0.094) for G20. No significant differences were found in inner medulla at the first ligation point for both G20 and G40, but as the increase of ligation time, the ADC values of inner medulla in G40 was significantly lower than baseline1. For both the 20min and 40min ligation, the cortex, outer medulla and inner medulla were all recovered immediately after the release of ligation (p>0.05), respectively. Each ADC mean value before, during and after ligation was shown in Fig. 2 (left) for G40 and in Fig. 3 (left) for G20.

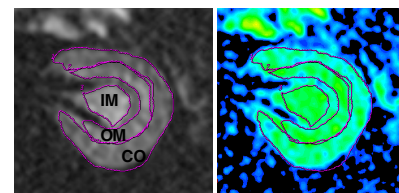


Fig. 1 ROIs on DWI image (b=0, left) and corresponding drawings on ADC map (right): cortex (CO), outer medulla (OM) and inner medulla (IM).

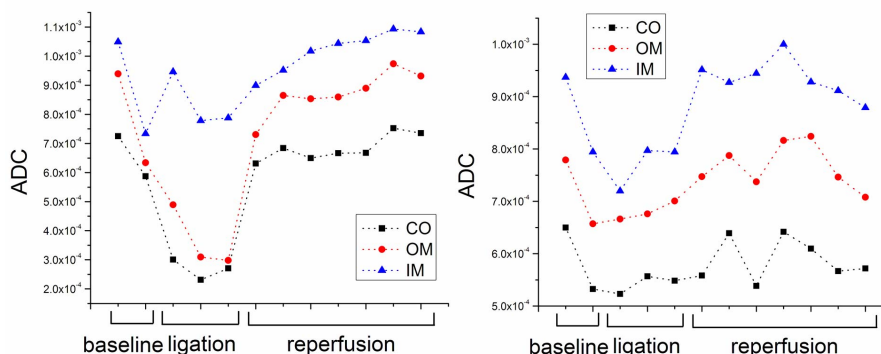


Fig. 2 ADC results of 40min ligation group: significant low values were found during ligation and gradually recovered back to baseline during reperfusion phases in left kidney (left); no significant differences were found in right kidney (right).

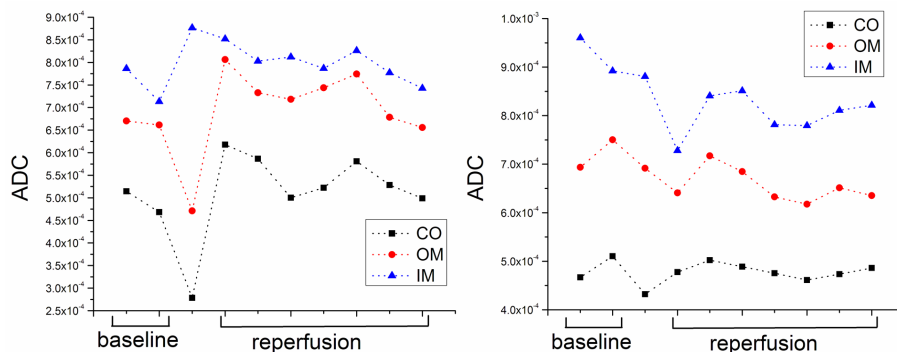


Fig. 3 ADC results of 20min ligation group: significant difference was found in ligation phase (left) and the right kidney maintain stable.

Conclusions:

In this study, we demonstrated that DWI is a sensitive MR tool for characterizing the renal dysfunction following normothermic ischemia and reperfusion injury. After the release of ligation, the ADC values of left kidney were increased to a value similar to the baseline while values of right kidney were found decreased after release of ligation. This may suggest a contribution to blood perfusion. No marked diffusion-restriction was found in left kidneys which might limited to short reperfusion time.

References:

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