TIME COURSE STUDY ON THE EFFECTS OF IODINATED CONTRAST MEDIUM ON INTRARENAL WATER TRANSPORT FUNCTION USING DIFFUSION-WEIGHTED MRI

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Introduction

Contrast-induced nephropathy (CIN) is a common iatrogenic event following intravascular injection of iodinated contrast medium (CM) (1). With increased utilization of iodinated CM during radiological or interventional procedures, CIN has become one of the most prevalent causes of acute renal failure (ARF), especially in patients suffering from diabetes or cardiovascular pathology (2). The pathogenesis of CIN, however, is currently unclear (3). This study aimed to quantify the intrarenal water diffusion responses to iodinated CM injection, as compared to a placebo, in ten healthy rabbits using a spin-echo & echo planar imaging (SE-EPI) DW-MRI technique(4, 5).

Materials and Methods

Ten New Zealand white rabbits were randomized to receive a 6 ml/kg body weight intravenous injection of clinically-used iopamidol-370 (n=7) or an equivalent amount of 0.9% physiological saline (n=3). Experiments were conducted in a 3.0 T whole-body MR scanner (GE Medical Systems, USA) with a commercial QUADKNEE coil. A sequential DW-MRI (b factors of 0 and 800 s/mm2) was performed to estimate the intrarenal apparent diffusion coefficient (ADC) at 24 hours before and 1h, 24h, 48h and 72h after administration. As with available preparation to limit the respiratory movements, the DW-MR images were almost free of motion artifacts in this study. ADC values obtained in the CO, OS, IS and IM were grouped into 'baseline', '1 h', '24 h', '48 h' and '72 h', respectively. One-Way ANOVA and Fisher's LSD test were performed to test the intrarenal water diffusion in response to iopamidol stimulation between different groups.

Results

Iopamidol produced a progressive ADC reduction in inner stripes of the renal outer medulla (IS) by 13.92% (P=0.05) at 1 hour, 17.52% (P=0.02) at 24 hours, 20.23% (P=0.01) at 48 hours and 16.31% (P=0.04) at 72 hours after injection. Cortical ADC was decreased by 14.14% (P=0.01) at 48 hours and 14.12% (P=0.01) at 72 hours after injection. Iopamidol produced slight decrease of ADCs in outer stripes of the outer medulla (OS) and inner medulla (IM) of kidney but without statistical difference. In control group, no significant ADC changes was observed in each anatomic compartment due to saline injection (P>0.05).

Discussion and Conclusion

Our experiments have demonstrated that it is feasible to monitor the time course effects of iodinated CM on the renal function in rabbit model utilizing a sequential DW-MRI. The results of this study indicated that the hyperosmotic iopamidol certainly produced a progressive reduction in intrarenal diffusion, particularly in IS of kidney (6). Results from the analysis on ADCs illustrated that the contrast-induced functional deficiency in renal parenchyma developed as early as one hour after injection, aggravated and lasted within the subsequent 48 hours, while slightly alleviated at 72 hours after injection. By using a relatively small FOV on 3.0T MR scanner to increase the spatial resolution and reduce susceptibility artifacts, each rabbit's images have sufficient spatial resolution and SNR to accurately outline the renal cortical and medullary regions (CO, OS, IS and IM) and subsequently quantify ADC values within these regions.

In conclusion, our time course study indicated that DW-MRI is an alternative noninvasive method for quantitative evaluation of renal function in normal or contrast-associated rabbit kidney models. The five-day sequential observation in our study demonstrated a persistent 72-hour reduction in renal water transport function due to iodinated CM administration. Moreover, the medullary diffusion deficiency may be helpful to understand the pathogenesis associated with CIN.

Table 1: Time course ADC changes in different compartments in response to iopamidol injection

Time course	ADC $\times 10^{-3}$ mm^2/s (N=6)			
	CO	OS	IS	IM
Baseline	2.03±0.24	1.85±0.22	1.73±0.25	1.77±0.20
Post-1h	1.95±0.21	1.79±0.17	1.41±0.17	1.67±0.19
Post-24h	1.88±0.16	1.67±0.22	1.36±0.13*	1.65±0.24
Post-48h	1.78±0.19*	1.60±0.27	1.33±0.25*	1.57±0.22
Post-72h	1.78±0.16*	1.64±0.28	1.39±0.21*	1.63±0.14

Table 2: Time course ADC changes in different compartments in response to saline injection

Time course	ADC $\times 10^{-3}$ mm^2/s (N=3)			
	CO	OS	IS	IM
Baseline	1.73±0.24	1.57±0.22	1.59±0.25	1.52±0.20
Post-1h	1.86±0.11	1.66±0.19	1.67±0.18	1.62±0.08
Post-24h	1.82±0.12	1.60±0.08	1.60±0.06	1.60±0.03
Post-48h	1.81±0.09	1.54±0.10	1.63±0.04	1.58±0.12
Post-72h	1.76±0.17	1.56±0.09	1.56±0.06	1.57±0.05

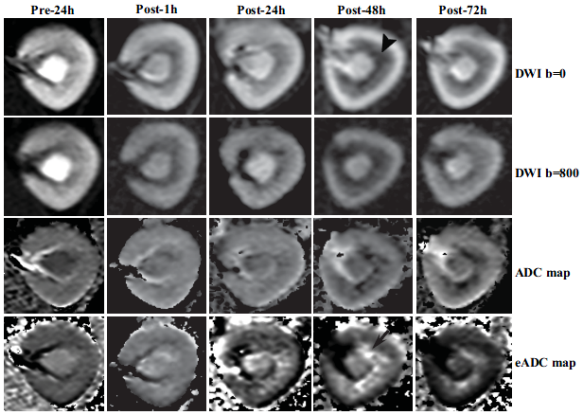

Figure 1: Rabbit renal DW-MRI images before and after iopamidol injection. The medullary signals on SE-EPI images (b=0 s/mm^2), DW images (b=800 s/mm^2) and ADC images, are reduced and aggravated heavily within 48 hours (black arrowhead). The remarkable hyper-intensity on medullary exponential ADC images (black arrow) indicates an impaired water transport function in this compartment due to iopamidol injection.

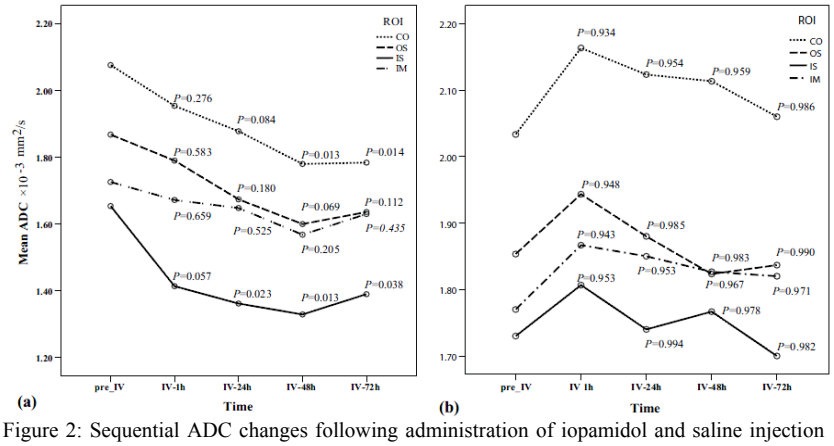

Figure 2: Sequential ADC changes following administration of iopamidol and saline injection in different renal compartments. **(a)** A progressive reduction in intrarenal ADC was observed by the first hour after iopamidol injection, lasted and aggravated until 24-48 hours. This CM induced reduction in diffusion mildly alleviated by 72 hours after injection. **(b)** Saline did not produce any statistically significant alteration in each renal compartment. Note: The *P*-values are a comparison relative to the baseline for the particular region of interest.

References

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