Diffusion-weighted magnetic resonance imaging findings of kidneys in patients with renal obstructive uropathy and high values of creatinine

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Aims and objectives

Hydronephrosis is an urinary flow disorder and etiology of it is due to the expansion of pelvicalyceal system including a very wide group of pathology. Urinary obstruction that causes hydronephrosis, may lead to an increase in retrograde pressure, tubular dysfunction, decrease in glomerular filtration rate and increase in serum creatinine levels. The early diagnosis and treatment of the obstructive hydronephrosis is very important because it may result in the loss of renal function. The data obtained by radiological imaging techniques plays an important role in diagnosis and follow-up of the obstructive hydronephrosis [1, 2]. Many of radiologic techniques has limitations because they are lack of quantitative information. Diffusion weighted magnetic resonance imaging (DW-MRI) of the kidneys gives noninvasive information on renal function in healthy volunteers, and it is also feasible in severely ill patients. It may provide information as to the degree of kidney dysfunction [3, 4].

The purpose of this study is to evaluate apparent diffusion coefficient (ADC) values by using DW-MRI in patients with obstructive uropathy and elevated serum creatinine levels.
Methods and materials

Study Population

Fifty patients (40 men and 10 women; mean age, 61±16.9 years; age range, 24-78 years old) with the diagnosis of chronic urinary obstruction due to urinary stone, tumour, or fibrosis detected by US imaging and higher serum creatinine levels (2±0.89) mg/dL were included in this study. There was a history of obstructive uropathy longer than 6 weeks in all patients. Twenty-six healthy volunteers (8 men and 18 women; mean age, 49±18.8 years; age range, 21-95 years) who had no history of renal disease and had normal creatinine levels (0.7±0.12) were included as a control group. All of the volunteers were having upper abdominal magnetic resonance imaging (MRI) for hepatic hemangioma. Serum creatinine values were obtained from all patients on the day of the MRI examination.

The study protocol was approved by the local ethics committee, and informed consent was obtained from all volunteers and patients.

MR Imaging

MRI was performed using with a 1.5T whole-body superconducting MR scanner (General Electric Signa hi-speed scanner, Milwaukee, WI, USA) equipment with hi-speed gradients. Body coil was used for all images. Axial T2-weighted fat saturation spin-echo images (TE:90, TR:5700, slice thickness:8 mm, intersection gap:1.5, number of excitation:4, matrix size:512 x 512) were obtained in all patients for demonstration of pelvicalyceal system. Diffusion weighted images (TE:72, TR:8000, FOV:30x30, slice thickness:5 mm, intersection gap:0, number of excitation:1, matrix size:128 x 128) were obtained using single-shot spin-echo, echo planar imaging (EPI) sequences with the following diffusion gradient b values: 100, 600, 1000 s/mm². Obtained maximum slice 26-40, examination time 30 seconds, direction of diffusion all. All images were obtained without breath-holding.

Image Analysis

The DW-MRI data were transferred to workstation (Advantege Windows, software version 2.0, GE Medical systems). We utilized monoexponential fitting of the diffusion decay curve. A circular region of interests (ROI) were placed in the corticomedullar junction for the measurement of ADC values normal and obstructed kidneys. For each kidney, three ROIs were placed middle portion of the kidneys. For each ROI; mean ADC values and standard deviations were calculated. All measurements were repeated different b values (100, 600, 1000 s/mm²). ADC maps were calculated automatically with the MR system and ADC values were expressed in square millimeters per second.

Statistical Analysis
Statistical analysis was performed with the SPSS 12.0 software packages program. The ADC values of the volunteers and patients are reported as the mean ± standard deviation. Independent samples \( t \) test was used for the comparison of paranchymal ADC values and the comparison of normal kidneys with the obstructed kidneys. A \( p \) value of less than .05 was considered to indicate a statistically significant difference.
Results

DW-MRI images were of diagnostic quality in all cases, and no cases were excluded from this study.

Seven of the patients had bilateral hydronephrosis. DW-MRI were obtained from 57 hydronephrotic kidneys of 50 patients and 52 healthy kidneys of 26 volunteers.

The significant decline were observed in renal signals with an increasing in the value of $b$, in the healthy and hydronephrotic kidneys. ADC maps were created from diffusion weighted echo-planar images. The color change was observed depending on increasing $b$ value and falling ADC coefficients, in both normal and hydronephrotic kidneys. The coloration was observed in hydronephrotic kidneys compatible with lower ADC values than normal kidneys (fig. 1).

The mean ADC values of normal kidneys for $b100$, $b600$, $b1000$ values were $(3.55\pm0.29) \times 10^{-3}$, $(2.67\pm0.49) \times 10^{-3}$, $(2.09\pm0.19) \times 10^{-3}$ mm$^2$/sn, respectively. The mean ADC values of obstructed kidneys with $b100$, $b600$, $b1000$ values were $(3.10\pm0.56) \times 10^{-3}$, $(2.45\pm0.55) \times 10^{-3}$, $(1.87\pm0.26) \times 10^{-3}$ mm$^2$/sn, respectively. Mean ADC values of hydronephrotic kidneys for $b100$, $b600$ and $b1000$ were statistically significant lower than normal kidneys ($p<0.001$) (fig. 2, 3).
Fig. 1: a,b,c,d,e,f. Axial ADC maps of normal (a,b,c) and hydronephrotic kidneys (d,e,f) with b100 (a,d), b600 (b,e) and b1000 (c,f) value. The red coloration compatible significantly high ADC value and yellow-green coloration compatible with lower ADC values.

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Fig. 2: Mean ADC values of normal renal parenchyma and hydronephrotic renal parenchyma, for b1000, b600 and b100 (mm²/sn).

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Fig. 3: Comparison between mean ADC values of obstructed kidneys and normal kidneys, for b1000, b600 and b100 (mm²/sn).

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Conclusion

DW-MRI is a non invasive method which gives reproducible information on renal function. These results indicated that the measurement of ADC values by DW-MRI has a potential value in the evaluation of the functional status of hydronephrotic kidneys. To our knowledge, there was no renal parenchymal DW-MRI study in the literature, in a large group who have obstructive uropathy and high creatinine levels. The ADC values of renal parenchyma in obstructive uropathy are significantly lower than the normal kidneys. However, further investigations are needed to support our results.
References


