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Role of diffusion- weighted magnetic resonance imaging in chronic renal parenchymal diseases

Ashraf T. Youssef[1], Mahmoud I. Aboelnor[1], Samar M. Mahmoud[1]*

[1] Department of radiodiagnosis, Faculty of Medicine, Fayoum University, Fayoum 63511, Egypt.

* Correspondence: Samar M. Mahmoud, samarmedhat140@yahoo.com; Tel.: (002) 01064670491.

Abstract

Introduction: Diffusion-weighted magnetic resonance imaging (DWI-MRI) may be considered a very important imaging technique because it is very safe, non-harmful, and depends on the movement of fluids inside human body cells.

Aim of the study: To detect the relationship between apparent diffusion coefficient (ADC) values and stages of chronic kidney impairment.

Subjects and Methods: 35 participants were recruited in 2020 from the Fayoum University hospital. 10 cases were normal with healthy kidneys (average serum markers and average carcinogenicity in the ultrasound (US)), while 25 were hypertensive or diabetic. The ADC values of the diseased and healthy kidneys were compared using DWI-MRI.

Results: ADC values were low in the diseased kidneys and high in the healthy kidneys.

Conclusion: The findings revealed an inverse relation between the ADC values and the stage of chronic kidney disease.

Keywords: DWI-MRI; ADC value; chronic Renal Parenchymal Diseases.

1. Introduction

Diffusion-weighted magnetic resonance imaging (DWI-MRI) is considered an important technique used for measuring changes that happen in diseased cells of different organs inside the human body. In cases of kidney disease, the apparent diffusion coefficient (ADC) values are measured and compared with estimated glomerular filtration rate (eGFR) [1]. It was known that DWI-MRI is used in brain diseases like infection, stroke, ischemia, and hemorrhage; now it is used in kidney diseases by measuring ADC values and comparing them with eGFR [2, 3]. Early detection of chronic kidney diseases (CKDs) is useful to start early treatment and reduce complications [4]. Serum markers, computerized tomography (CT), and ultrasound (US) scanning have traditionally been used in the diagnosis of CKD and determining the stage of the disease, but they were found to be insufficient for detecting kidney function; additionally, contrast media can be toxic and cause

additional damage [5, 6]. DWI-MRI visualizes fluid flow among human body cells; using it to calculate ADC values can be highly beneficial in CKD [7].

The current study aimed to detect the relationship between ADC values and stages of chronic kidney impairment.

2. Subjects and methods

2.1. Subjects

35 participants were recruited in 2020 from the Fayoum University hospital. Ten cases were normal with healthy kidneys (average serum markers and average carcinogenicity in the US), while 25 were hypertensive or diabetic. Our study didn't include any children or cases with general contraindications to MRI.

2.2. Methods

A full history was taken, along with present history and complaints. Serum markers were also measured. Technical considerations: All MRI examinations will be performed with a 1.5-T scanner (Acheiva, Philips, and Holland). All MRI reviews will be achieved with the following parameters: repetition time (TR); 1580 MS, echo time (TE); 60 MS, slice viscosity; 1–5 mm, receiver bandwidth; 1158 kHz/pixel (FOV); 40 cm, matrix size; 164×159.

2.3. Statistical Analysis

Data collected and coded to grease data manipulation and double entered into Microsoft Access, and data analysis performed using SPSS software interpretation 22 in Windows 7 (SPSS Inc., Chicago, IL, USA). Simple descriptive analysis in the form of numbers and chances of qualitative data, calculation means as a central tendency dimension, and standard diversions as a measure of dispersion of quantitative parametric data. For quantitative data, an independent sample t-test was used to compare quantitative measures between two independent groups. A one-way ANOVA test is used to compare quantitative measures between more than two independent groups of quantitative data. For qualitative data, the Chi square test is used to compare two or more qualitative groups. bi-variate Pearson correlation test to test the association between variables. Perceptivity and particularity tests for testing a new test with ROC wind. The P-value<0.05 was considered as statistically significant

3. Results

The mean age of the study group was 47.6±17.6 years old, ranging between 20 and 75 years. 56.7% were males versus 43.3% were females. eGFR of normal kidneys was 90 ml/min/1.73m^2; eGFR of stage 1 of chronic nephropathy was 90 ml/min/1.73m^2 with little amount of protein in urine; while eGFR of stage 2 chronic nephropathy was 60–90 ml/min/1.73m^2 with more protein in urine and decreased kidney echogenicity. Stage 3 showed an eGFR measuring 30-44 ml/min/1.73m^2, while

stage 4 was 15-30 ml/min/1.73m^2. In these two stages, the kidneys were very damaged. In stage 5, the kidneys were completely non-working with an eGFR < 15 ml/min/1.73m^2.

There was no statistically significant difference (*P>0.05*) in ADC level for different genders. That indicated no effect of these variables on the ADC level. On the other hand, there was a statistically significant difference (*P<0.05*) in ADC level between different medical histories and kidney disease staging, with a higher mean among cases with no chronic disease and no kidney impairment and a statistical decrease in ADC level when kidney impairment stages increased (Table 1).

Table 1: Comparisons of ADC in different disease characters.

Variables		ADC	*P-value*
Sex	**Male**	1.87±0.31	0.1
	Female	1.72±0.61	
Medical History	**None**	2.21±0.24	<0.001
	Hypertension	1.73±0.19	
	Diabetes mellitus	1.71±0.16	
	Hypertension and Diabetes mellitus	1.74±0.09	
Stage of kidney impairment	**Stage 0**	2.17±0.24	<0.001
	Stage I	1.98±0.15	
	Stage II	1.79±0.07	
	Stage III	1.74±0.06	
	Stage IV	1.57±0.11	
	Stage V	1.52±0.08	

As regards the sensitivity and specificity test for ADC level in detection of chronic kidney disease staging, the table illustrated higher sensitivity and specificity of ADC level in diagnosis of stage 0 and stage I with sensitivity of (100% and 100%) and specificity of (91.7% and 70.4%) at cutoff values of 1.91 and 1.84, respectively. For stage II, the sensitivity was 85.7% but with a low specificity of 41.7%; for stages IV and V, the sensitivity and specificity of the ADC level were very low (Table 2 and Figure 1).

Table 2: Sensitivity and specificity of ADC level in diagnosis of CKD staging.

Variable	Sensitivity	Specificity	AUC	Cut off point
Stage 0	100%	91.7%	97.2%	1.91
Stage I	100%	70.4%	80.2%	1.84
Stage II	83.3%	41.7%	56.3%	1.70
Stage III	85.7%	30.4%	40.4%	1.66
Stage V	60%	4%	3.6%	1.5%

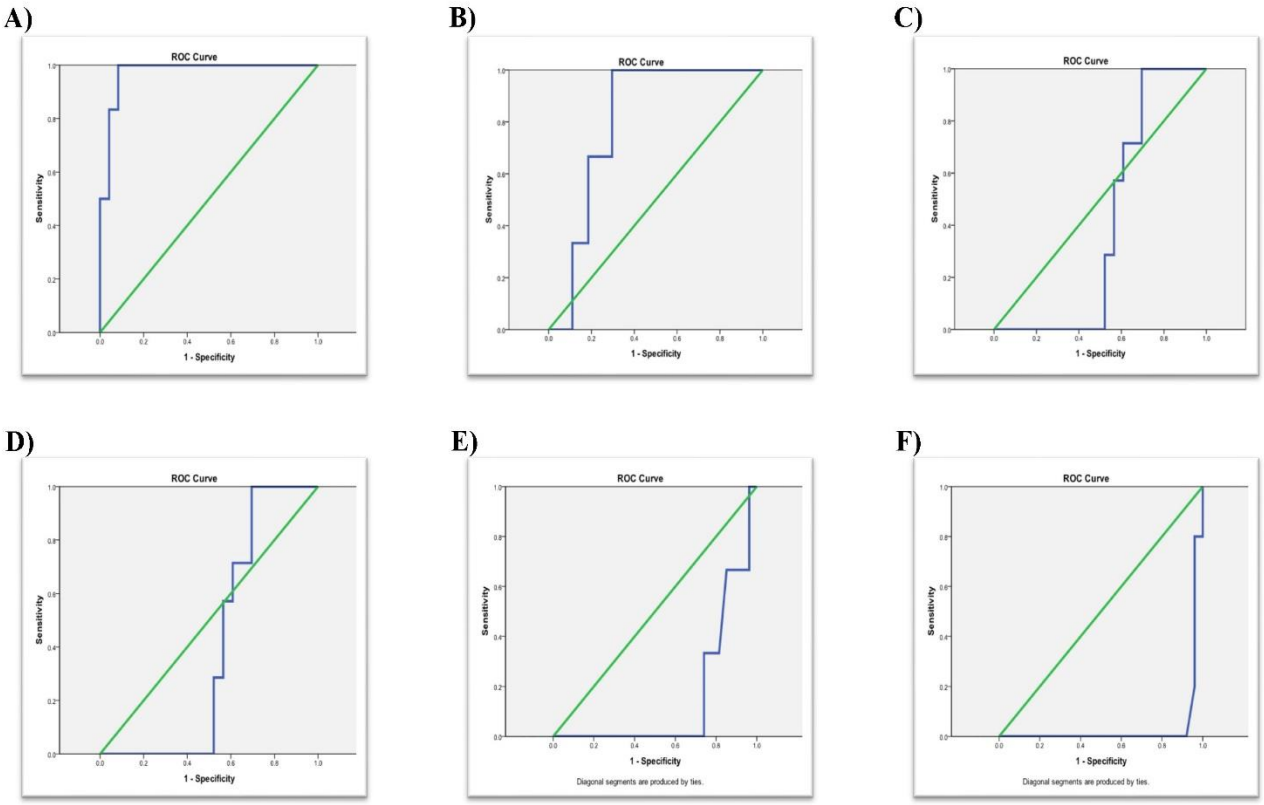

Figure 1: ROC curve analysis of different ADC findings in accordance to different CKD diagnostic stages. A) Stage 0, B) Stage I, C) Stage II, D) Stage III, E) Stage IV, F) Stage V.

As an example, for the current findings, a healthy woman aged 27 years old with a BU of 32 mg/dl, serum creatinine measuring 0.6 mg/dl, and an eGFR of 139 ml/min/1.73 m^2. The US findings showed average kidney size and echogenicity. Coronal T2WI with normal kidneys measured DWI, and ADC maps showed decreased renal parenchyma in both kidneys. The mean ADC value of one kidney was 2.32×10^{-3} mm2/s, and that of the other kidney was 2.33×10^{-3} mm^2/s. The mean ADC of two kidneys was 2.2×103 mm^2/s (Figure 2).

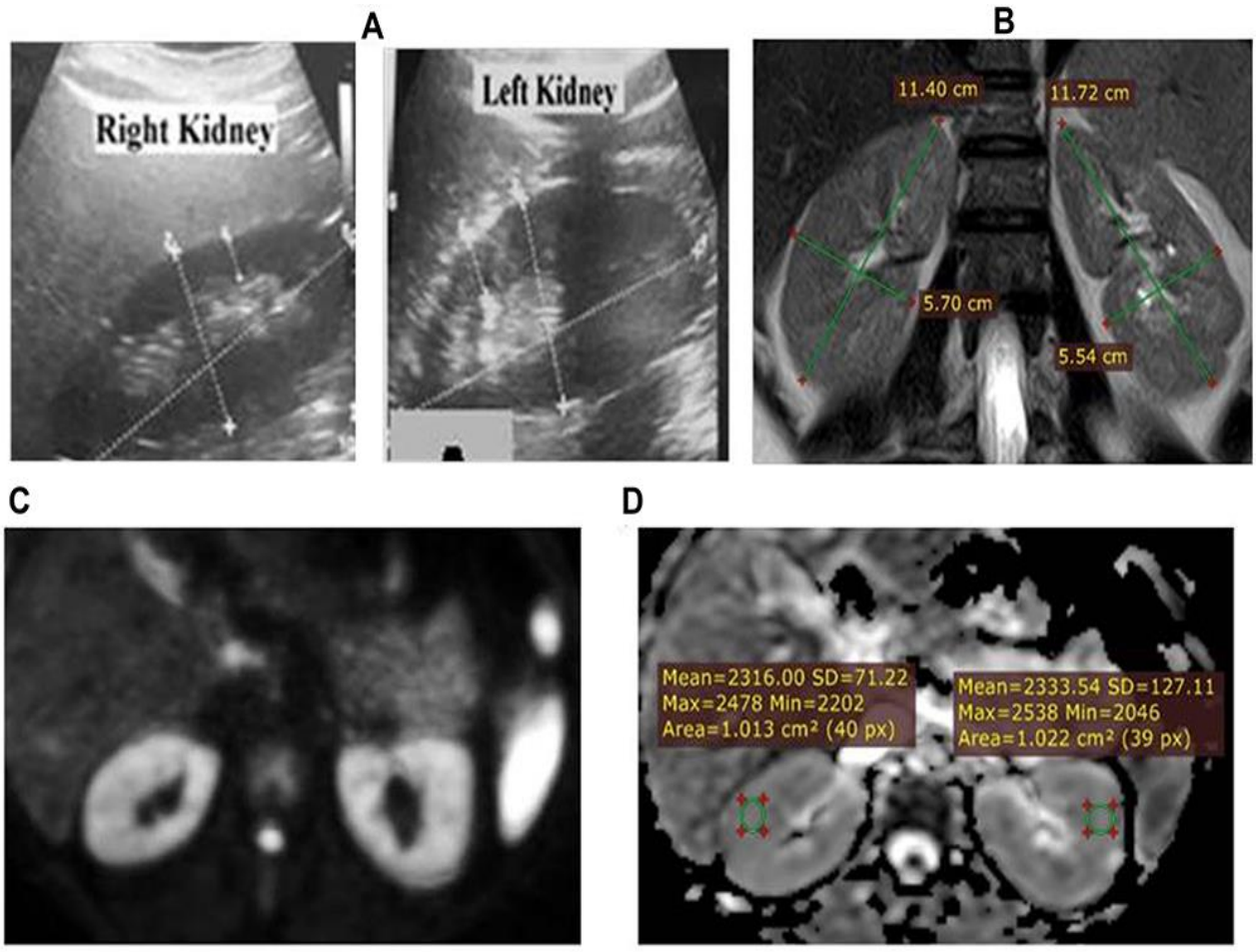

Figure 2: An example of the US findings.

4. Discussion

The age of cases ranged from 20 to 75 years, with a mean age of 47.6 years, with 56.7% being males versus 43.3% being females (17 males and 13 females).

Among study group 16.7% had, no chronic diseases with 50% had hypertension, 26.7% had Diabetes mellitus, and 6.7% had both hypertension and Diabetes mellitus. In this study, there was no statistically significant difference in ADC level between genders. That indicated no effect of these variables on the ADC level. On the other hand, there was a statistically significant difference ADC level between different medical histories and kidney disease staging, with a higher mean among cases with no chronic disease and with no kidney impairment and a statistical decrease in ADC level with an increase in kidney impairment stages. The mean ADC values of different stages of CKD were not the same and showed declining values with increasing stages. There was a statistically significant negative correlation between ADC level and creatinine level among cases, which indicated that an increase in creatinine level would be associated with a decrease in ADC level. There was no

markedly different ADC value between the right and left kidneys in this study. As regards the sensitivity and specificity test for ADC level in detection of CKD staging, there is higher sensitivity and specificity of ADC level in diagnosis of stage 0 and stage I with sensitivity of (100% and 100%) and specificity of (91.7% and 70.4%) at cutoff values of 1.91 and 1.84, respectively. For stage II, the sensitivity was 85.7% but with low specificity (41.7%); for stages IV and V, the sensitivity and specificity of ADC levels were relatively low with respect to stages I and II of chronic renal impairment. Likewise, other studies found that the ADC values of healthy kidneys were higher than those of diseased ones, and they also found an inverse relation between the ADC values and the stage of the disease [8, 9]. Other studies found a positive relationship between ADC values and eGFR [10, 11].

Conclusions

DWI-MRI might be used for early detection of renal impairment by calculation of ADC values, as we found that when the stage of kidney impairment increases, the ADC value decreases, so this is helpful to avoid biopsy and contrast media.

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Conflicts of Interest: All authors declare no conflict of interest.

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