Original Article

Using 1.5 T Diffusion-Weighted Magnetic Resonance Imaging to Classify Small Solid Renal Tumors

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Abstract

Background: Imaging techniques are essential to predict the origin of renal tumors and suggest a management plan. **Objectives:** The current research aimed to assess the role of diffusion-weighted magnetic resonance imaging (DW-MRI) in the differentiation among incidentally detected small renal tumors concerning clinical behavior. **Materials and Methods:** The current research was conducted at the Hilla Teaching Hospital in Babylon, Hillah, Iraq. The study included 25 patients with small-size renal tumors (≤4 cm). Examination of patients was done using a 1.5 T MRI scanner (Achieva, Philips Medical Systems, The Netherlands) using a SENSE body coil. All enrolled patients were subjected to T2-weighted image that is, coronal HASTE (T2WI), axial GRE T1WI (in-phase and out-of-phase), and axial TSE T2WI. Post-contrast T1 axial and DW-MRI and apparent diffusion coefficient (ADC) map for all patients. **Results:** The average ADC of malignant tumors was higher in a significant manner than that of tumors that are benign, 1.33 ± 0.02 versus $1.07 \pm 0.17 \times 10^{-3}$ mm/s, respectively ($P < 0.001$). A receiver operating characteristic curve test to define the ADC cutoff value that can predict malignant renal tumors in terms of accuracy, sensitivity, and specificity was performed. The under-curve area was 0.878, the sensitivity was 100%, and the specificity was 77.8% for a cutoff value for ADC of $>1.1 \times 10^{-3}$ mm/s. **Conclusion:** The use of MRI of the DW kind permits high accuracy in differentiating the clinical behavior of small kidney cell tumors and can be used in clinical practice in cases where renal percutaneous biopsy is inconclusive or difficult to perform.

Keywords: Magnetic resonance imaging, small solid, renal tumors

Introduction

The global spread of cross-sectional imaging all over the world has permitted the incidental discovery of small-size renal tumors in increasing frequency.[1-3] The biological behavior of these tumors is highly variable, ranging from totally benign neoplasms to types with high-grade histological patterns and aggressive clinical outcomes.[4-6] Out of all malignant neoplasms in the adult age group, renal cell carcinoma (RCC) accounts for approximately 3%.[7] The incidental discovery of renal cell tumors using cross-sectional imaging methods, including magnetic resonance imaging (MRI) and computed tomography (CT), has made a higher incidence of RCC in adults.[7] These discovered tumors are often small in size 4 cm or less in diameter. Based on histopathological reports, the benign tumors are mostly oncocytoma and angiomyolipoma, whereas, malignant tumors are mostly RCC.[8,9] The decision about how to approach such tumors is solely based on identifying the histological nature of these tumors.[3] However, there is a great deal of controversy concerning the effectiveness of practicing kidney biopsy through a percutaneous route to identify the nature of such tumors with a rate of uninformative histological reports reaching up to 23%[10-12] leading to the risk of operating benign kidney masses in up to 33.6%.[13,14]

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Imaging techniques are, therefore, essential to predict the origin of renal tumors and suggest management plans. It can be utilized to differentiate RCC from benign neoplasms, by identifying histological types and biological grade where possible. CT is nowadays the most often utilized way for initial detection and staging of such tumors.[3] Currently, contrast-enhancement CT and contrast-enhancement MRI are the two principal imaging modalities available to evaluate the characteristics of renal neoplasms[15]; however, the possibility of "nephrogenic systemic fibrosis" that is, contrast-induced by MRI[16] and renal injury by CT-scan[17] have critically highlighted the need for nonenhanced and noninvasive imaging modality to detect and categories the features of renal neoplasms.[18]

Diffusion-weighted MRI (DW-MRI) is commonly used to differentiate between benign and malignant tumors. Inside tissues, the movement of water molecules that is, random Brownian is impeded by interactions with macromolecules and cell membranes, resulting in this approach. The apparent diffusion coefficient (ADC) is an evaluation of the amount of tissue water transport that may be utilized to quantify pathological alterations in the absence of contrast. According to certain studies, the ADC derived by DW imaging (DWI) can assist in the distinction of particular kidney lesions and has some use in the categorization and grading of malignant kidney tumors.[18] Little number of studies, however, have concentrated on the ability of DW-MRI for the differential and initial detection of renal masses 4 cm or less, which is the criterion frequently utilized in medical practice for Tumor, Node, and Metastasis staging of RCC.[19] The current research aimed to assess the participation of DW-MRI in the differentiation among incidentally detected small renal tumors concerning clinical behavior.

Materials and Methods

The current cross-sectional research was done in the Hilla Teaching Hospital in Babylon, Hillah, Iraq. The study included patients with small-size renal tumors (≤4 cm). Children were excluded from the study because of the need for anesthesia, and also those with tumors>4 cm in diameter were excluded because of the artifact effect.

Examination of patients was done using MRI with 1.5 System of Tesla (Achieva, Philips Medical Systems, The Netherlands) using a SENSE body coil. All enrolled patients were subjected to T2-weighted image that is, coronal HASTE (T2WI), axial GRE T1WI (in-phase and out-of-phase), and axial TSE T2WI. Coils that are phased array, including breath-hold DWI and nonenhanced MRI, on all patients. The study was initiated on April 13, 2020, and ended on June 10, 2021. Post-contrast T1 axial and DWI and ADC map for all patients.

Ethical approval

The study followed the guidelines outlined in the Declaration of Helsinki for conducting research with minimal risk to participants. Before collecting any samples, we obtained the patient's verbal consent. Document 109 dated March 16, 2020 indicates that the local ethics committee evaluated and approved the research protocol, subject information, and permission form.

Statistical Analysis

Data about age, gender, and the results of the ADC were transferred into a spreadsheet of the Statistical Package for Social Sciences (IBM Corp., Armonk, NY, USA) and Microsoft Office Excel software for statistical description and analysis. The chi-square test was used to study differences in ratios and independent samples. Student t test was used to study the differences in means. The level of significance was considered at $P \leq 0.05$.

Results

A cross-sectional study of 25 patients characteristics that are demographic of patients with renal tumors are shown in Table 1. Contrasting of average values of "ADC" between benign and malignant kidney pathologies is shown in Table 2. The average ADC of malignant lesions was greater in a

Table 1: Demographic characteristics of patients with renal tumors

Characteristic	Total *n* = 25	Benign *n* = 9	Malignant *n* = 16	*p*
Age (years)				
Range	26–72	30–57	26–72	0.118 I
Mean ± SD	46.92 ± 13.32	41.33 ± 10.50	50.06 ± 13.99	NS
20–40, *n* (%)	10 (40.0%)	5 (55.6%)	5 (31.3%)	
41–60, *n* (%)	11 (44.0%)	4 (44.4%)	7 (43.8%)	
> 60, *n* (%)	4 (16.0%)	0 (0.0%)	4 (25.0%)	
Gender				
Male, *n* (%)	13 (52.0%)	3 (33.3%)	10 (62.5%)	0.325 Y
Female, *n* (%)	12 (48.0%)	6 (66.7%)	6 (37.5%)	NS

NS: not significant, Y: Yates correction test, I: independent samples *t* test, *n*: number of cases

Table 2: Contrasting of average values of "ADC" between benign and malignant kidney pathologies

Characteristic	Total $n = 25$	Benign $n = 9$	Malignant $n = 16$	p
ADC ($\times 10^{-3}$ mm/s)				
Range	0.89–1.4	0.89–1.4	1.3–1.37	< 0.001 I ***
Mean ± SD	1.24 ± 0.16	1.07 ± 0.17	1.33 ± 0.02	

n: number of cases, I: independent samples *t* test.
***: Significant at $P \leq 0.001$

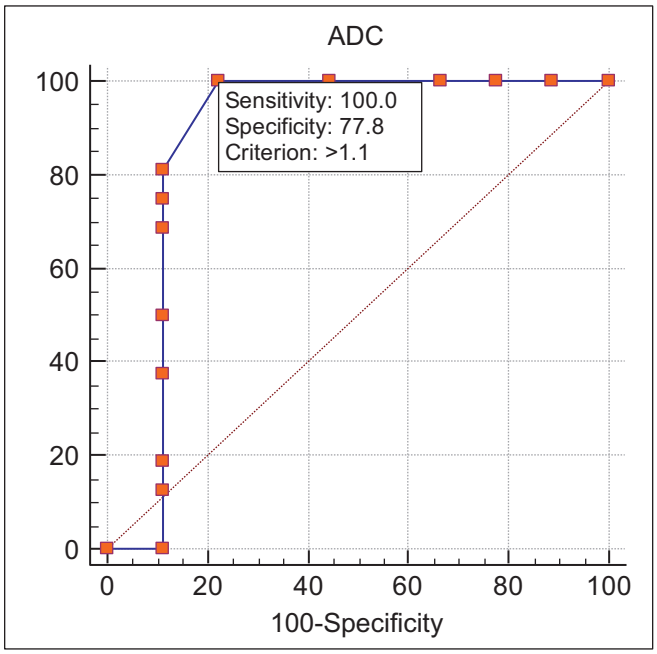

Figure 1: ROC curve tests to define the cutoff value of apparent diffusion coefficient that can predict malignant renal tumor in terms of accuracy, sensitivity, and specificity

Table 3: Characteristics of ROC curve

Characteristic	Result
Cutoff value	>1.1 × 10^{-3} mm/s
AUC	0.878
95% CI	0.686–0.974
P value	<0.001***
Sensitivity %	100
Specificity %	77.8
Accuracy %	87.8

CI: confidence interval, AUC: area under the curve
***Significant at $P \leq 0.001$

significant manner than that of tumors that are benign, 1.33 ± 0.02 versus 1.07 ± 0.17 × 10^{-3} mm/s, respectively ($P < 0.001$). A receiver operating characteristic (ROC) curve test to define the ADC cutoff value that can predict malignant renal tumor in terms of accuracy, sensitivity, and specificity was performed and the results are shown in Figure 1 and Table 3. The area under the curve (AUC) was 0.878, the sensitivity was 100%, and the specificity was 77.8% of a cutoff value for ADC of >1.1 × 10^{-3} mm/s.

Discussion

The detection of renal cell tumors of <4 cm (small tumors) in radiological examination using cross-sectional imaging has become more common in everyday clinical practice. Small size in renal cell tumors does not exclude malignant biologic behavior; therefore, it became mandatory to find a way to detect the histological nature of such tumors particularly when the efficacy of percutaneous biopsy is not fruitful in a substantial proportion of detected cases. The use of contrast with imaging techniques helps predict the biological behavior of such renal tumors, but the use of contrast is not free of adverse effects, and finding a noninvasive imaging tool with similar efficacy is of principal importance.

Pieces of literature nowadays raised the possibility of the use of DW- MRI in such missions and the concept of ADC received much attention by both radiologists and urologists to make clear plans about how to deal with such tumors. In our study, we found a significant difference in mean ADC between benign lesions and malignant ones and this suggests the ability of ADC value to predict malignant behavior at a certain cutoff value. For that reason, we conducted an ROC curve analysis and found that an ADC value of >1.1 × 10^{-3} mm/s can predict a diagnosis of malignant renal tumor with excellent accuracy. The main limitation of our study was the small sample size and we hope in the future we can collect a larger sample size to validate the results of the current study.

In one previous study, Zhang *et al.*[18] assessed the use of MRI that is, DW in the detection of malignant potential of small renal tumors, and their study, nonenhanced MRI's area under curve specificity, sensitivity, and AUC for diagnosing RCC were 81.2, 93.9, and 0.919, respectively, whereas DW-MRI combined with nonenhanced MRI's specificity, sensitivity, and AUC, for detecting RCC were 100, 97, and 0.998, respectively. This meant that MRI that is, DW gave more details than MRI that is, nonenhanced, and that the two together brought about detection performance comparable to contrast enhanced-CT.[19]

Furthermore, in contrast-enhanced imaging techniques, the utilization of MRI that is, DW, and MRI that is, nonenhanced may reduce the possibility of renal impairment due to contrast and systemic fibrosis that is, nephrogenic. The specificity, sensitivity, and AUC of MRI that is, DW for detecting kidney carcinoma except for angiomyolipomas were 80, 86, and 0.856, respectively, according to Taouli *et al.*[20] Because of our limited number of patients and the varied groups of conditions

that are benign in our research, the sensitivity and AUC were greater than those in our investigation and those of Zhang *et al.*[18] Furthermore, Taouli *et al.*'s[20] research found that the average ADC of kidney malignant tumors was substantially less than that of conditions that were nonmalignant ($P < 0.01$), corroborating our findings.[21] Other several authors corroborating our findings.[21-23]

Conclusion

The use of MRI of the DWd kind permits high accuracy in differentiating the clinical behavior of small kidney cell tumors and can be used in clinical practice in cases where renal percutaneous biopsy is inconclusive or difficult to perform.

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Conflicts of interest

There are no conflicts of interest.

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