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Research Paper

Role of Multi-Parametric Magnetic Resonance Imaging (mpMRI) in the Differentiation of Different Types of Solid Renal Masses

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ABSTRACT:

BACKGROUND:

In the last decade, the incidence of renal cell carcinoma (RCC) has been rising, with the greatest increase observed for solid tumors. Magnetic resonance imaging (MRI) protocols and algorithms have recently been available for classifying RCC subtypes and benign subtypes.

OBJECTIVE:

To assess the role of multi-parametric magnetic resonance imaging (mpMRI) in differentiation of different types of solid renal masses.

PATIENTS AND METHODS:

This is a cross-sectional study performed in Al- Imamian Al- Kadhmain medical city and was conducted on 41 patients having renal masses previously diagnosed with ultrasound and/or computed tomography, referred to the radiology department. All patients were subjected to full history taking, radiological examination inform of mpMRI of the upper abdomen and histopathological correlation of surgical specimens.

RESULTS:

Malignant solid renal mass lesion is commoner than benign masses. Lesions that shows low signal intensity on T2WI (lipid poor AML and papillary RCC), high to intermediate T2WI seen in other types of solid renal masses, in phase opposed phase T1WI was very helpful in identifying the fat content of different types of solid renal masses in which macroscopic fat content seen as India ink artefact on opposed phase and only seen a lipid rich AML, microscopic fat content was seen in some of the clear cell RCC and all lipid poor AML. The mean ADC value of malignant lesions was very helpful in this study it was significantly lower than that of benign lesions of about 1.5 $*10^{-3}$ $mm^2/sec.$ for malignant solid renal masses and 2.03 $*10^{-3}$ mm^2/sec for benign solid renal masses. Dynamic contrast MRI showed three types of curves: progressive, plateau and washout dynamic curves, progressive type dynamic curve seen only in papillary RCC, washout type dynamic curve seen in clear cell RCC, oncocytoma, chromophobe RCC and AML, plateau type dynamic curve seen in both clear cell RCC and chromophobe type RCC.

CONCLUSION:

Multiparametric MR imaging as a noninvasive imaging method provides critical information that can help in differentiation of the most common solid renal masses, T2WI play an important role in differentiation between different types of solid renal masses and narrow the differential diagnosis, macroscopic fat content seen as India ink artefact on opposed phase and seen in lipid rich AML, DWI play vital role in differentiation between benign and malignant renal masses, in which malignant solid renal masses show diffusion restriction, while benign masses show no restriction ,DCE MRI play no significant role in differentiation BETWEEN SOLID RENAL MASSES.

KEYWORDS: mpMRI, solid renal masses, Magnetic resonance imaging.

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INTRODUCTION:

Renal cell carcinomas comprise the mainstay of kidney-tumors and are responsible for 80–85% of early renal malignancies as well as roughly 3% of adult tumors [(1)].

In order to increase overall patient survival and choose the optimal course of treatment, kidney malignancies must be characterized. Kidney-tumors are becoming increasingly identified in clinical practice due to a lot of imaging techniques. Therefore, it is even more crucial to precisely characterize these lesions [2]. Kidney-tumor specimen may be used to establish a pathological diagnosis for kidney-tumor that are not clearly defined. [3]. Apart from indicating the histologic grade of a tumor and aiding in the distinction between various subtypes of kidney-tumors, magnetic resonance imaging (MRI) can play a vital role in guaranteeing that patients obtain appropriate care and refrain from superfluous treatments. Additionally, it is a helpful noninvasive imaging tool for follow-up after treatment and for patients who are actively followed for renal masses [4]. It has been demonstrated that the MpMRI can identify cystic renal masses [5].

AIM OF THE STUDY:

To assess the role of multiparametric magnetic resonance imaging (mpMRI) in differentiation of different types of solid renal masses.

PATIENTS AND METHODS:

This is cross sectional prospective study in which categorized data when expressed as number, percentage and cross tabulation, while numerical data where expressed as mean and standard deviation, compares of signal intensities and enhancement pattern between the benign and malignant solid renal masses was done using unpaired t test. The software used was Microsoft excel 2010. P value less than 0.05 was considered significant.

Patient inclusion criteria:

This study included patients with kidney masses previously detected by CT scan or ultrasound, regardless of age or gender.

Patient exclusion criteria:

Patients with renal impairment and renal masses less than 1 cm in size were excluded from the study, as were patients with metallic devices.

Scan protocol and parameters

Patients who met the requirements for inclusion were paired with the following protocols: Making History - Personal details like name, gender, and age. A history of similar issues in the family. - Medical history, encompassing previous surgeries, treatments, tests, and symptoms currently experienced.

The study used upper abdomen contrast-enhanced MRI. A surface coil with respiratory triggering and a superconductive magnet (ACHIEVA, Philips Medical System/Netherlands 1.5 Tesla) were used for the MRI, a morphological examination of the upper abdomen was obtained using the following sequences:

AxialT1 weighting turbo field echo (TFE)

Single-shot turbo spin echo (TSE) with axialT2-weighting.

Fat suppression using axial T2-weighted single-shot TSE [spectral selection attenuated inversion recovery(SPAIR)].

Single-shot TSE sequences with coronal T2-weighting.

Axial diffusion weighted sequence.

Axial Tl-weighted gradient echo sequence for dynamic imaging.

Using 0.1 mmol /kg intravenous gadolinium contrast (magnevist), immediately followed by three breath-hold periods with three scan series per breath-hold.

1. The corticomedullary phase begins 30-40 seconds after injection. Intense enhancement of the renal cortex while the medulla remains relatively less enhanced.

2. The nephrogenic phase begins 60-90 seconds after contrast administration.

3. The excretory phase begins 3 minutes after contrast administration.

Histopathological assessment

The definitive diagnosis in patients with operable masses was determined by analyzing the histopathologic outcome of the resected masses. The results of histology findings and follow-up results were correlated with the mpMRI findings, including pictures, for every patient.

Limitation of the study

- Lack of standardization of ADC value
- Small sample volume
- Need of IV contrast which cannot be given in patient with high renal indices

RESULTS:

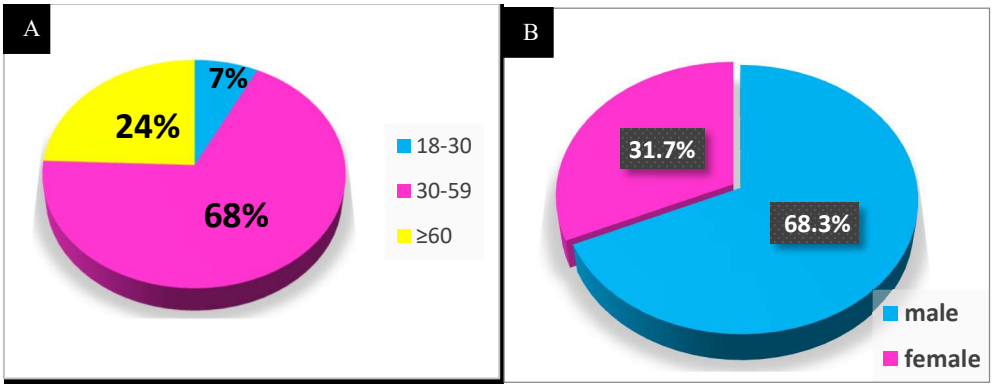

Figure 1 A: showing the age distribuation of patient who presented with solid renal masses, B: showing the gender distrbuation of patient presented with solid renal masses.

Table 1: Comparison of different MRI T2 weighted image (T2WI) MRI signal intensities in compares to renal cortex.

Tumor subtype	T2WI signal intensity			P value
	Moderate to high SI	Isointense SI	Low SI	
Clear cell renal cell carcinoma (n=24)	24 (100%)	0 (0.0%)	0 (0.0%)	<0.001
Papillary renal cell carcinoma (n=5)	0 (0.0%)	0 (0.0%)	5 (100%)	
Chromophobe renal cell carcinoma (n=3)	3 (100%)	0 (0.0%)	0 (0.0%)	
Oncocytoma (n=2)	2 (100%)	0 (0.0%)	0 (0.0%)	
Angiomyolipoma (lipid rich) (n=4)	1 (25%)	3 (75%)	0 (0.0%)	
Angiomyolipoma (lipid poor) (n=3)	0 (0.0%)	0 (0.0%)	3 (100%)	

Table 2: Fat content analysis in solid renal masses on in-phase and opposed-phase T1-weighted imaging.

Tumor Subtype	n	Macroscopic Fat		Microscopic Fat		P-value
	Tumor Subtype n	*Present n (%)*	*Absent n (%)*	*Present n (%)*	*Absent n (%)*	P-value
Clear cell RCC	24	0 (0.0)	24 (100.0)	3 (12.5)	21 (87.5)	<0.001
Papillary RCC	5	0 (0.0)	5 (100.0)	0 (0.0)	5 (100.0)	
Chromophobe RCC	3	0 (0.0)	3 (100.0)	0 (0.0)	3 (100.0)	
Oncocytoma	2	0 (0.0)	2 (100.0)	0 (0.0)	2 (100.0)	
AML (lipid-rich)	4	4 (100.0)	0 (0.0)	3 (75.0)	1 (25.0)	

Tumor Subtype	n	Macroscopic Fat		Microscopic Fat		P-value
	Tumor Subtype n	*Present n (%)*	*Absent n (%)*	*Present n (%)*	*Absent n (%)*	P-value
AML (lipid-poor)	3	0 (0.0)	3 (100.0)	3 (100.0)	0 (0.0)	

Table 3: Apparent diffusion coefficient (ADC) value for solid renal masses.

Histopathology	Tumor subtype	Subtype ADC Mean ±SD	Total ADC Mean ±SD	P value
Malignant	Clear cell renal cell carcinoma	1.64±0.122	1.507±0.087	<0.001
	Papillary renal cell carcinoma	1.468±0.065		
	Chromophobe renal cell carcinoma	1.417±0.076		
Benign	Oncocytoma	2.090±0.197	2.039±0.103	
	Angiomyolipoma (lipid rich)	2.039±0.074		
	Angiomyolipoma (lipid poor)	2.044±0.038		

Case from the study.

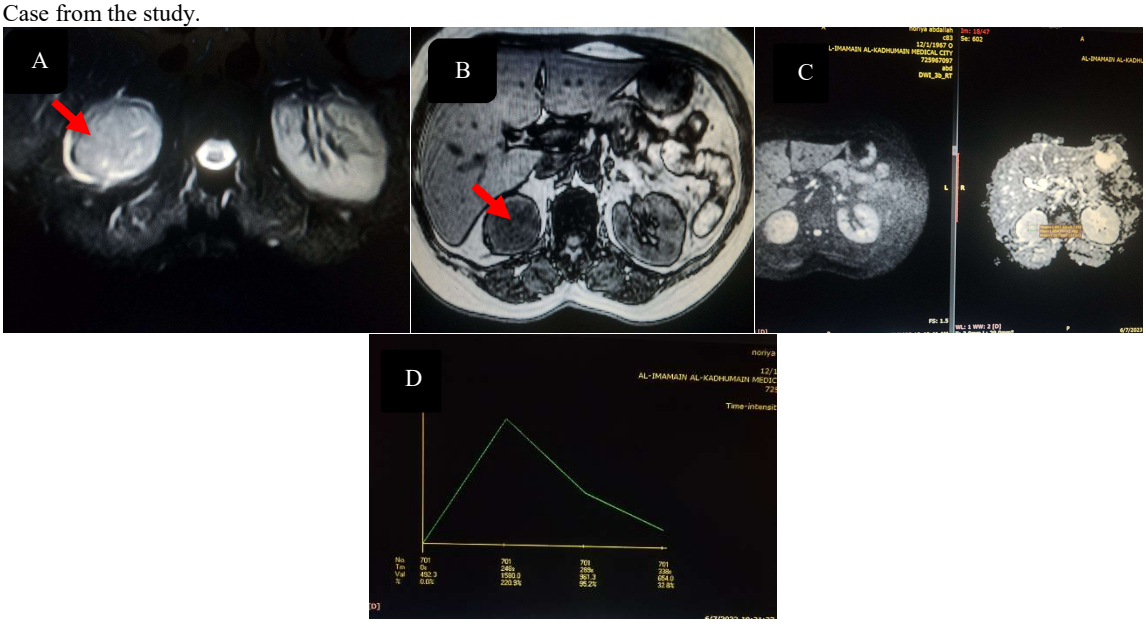

Figure 2: 45 years old with clear cell RCC. (A) Axial T2WI shows high SI mass lesion within right kidney (red arrow). (B) Axial section opposed phase T1WI in which there is signal drop out on out of phase which represent microscopic fat. (C) Axial section that represent ADC value at p value (800) shows diffusion restriction , ADC value measuring 1.66 (*10 $^{-3}$ mm^2/sec) (D) Axial section dynamic contrast-enhanced that show washout type dynamic curve.

DISCUSSION:

In current study, the total number of patients who had renal tumor and investigated by mpMRI at the radiology department in Al-Imamian Alkadhemian medical city was 41 (28 males and 13 females) patients. The patient's age in our study was ranging from 18

to 70 years with a mean of 48 ± 11.87 years. In comparison with other studies, a retrospective study conducted in Gunma University hospital in Japan from April 2005 to August 2007 which included 47 patients, and involved 32 males and 15 females with age ranged from 21- 85 years and mean of 43 years [6], Another study included 19 adult patients with pathologically verified renal tumors and showed an age range from 42 to 73 years and included seven women and 12 men, mean age was 59.5 years [7], Also a retrospective study in 2009 which included 109 renal lesions in 64 patients (46 men and 18 women), the age range was 24-85 years and the mean age was 60.7 years [8].

The most frequent solid renal masses in this study were clear cell carcinoma which represent 58.5% of the total percentage, followed by angiomylolipomas (17.07), these results are in agreement with further study Abdel Hamed M et al [9]. The most common malignant sub type of renal cell carcinoma was clear cell carcinoma (58.53), followed by papillary type of renal cell carcinoma (12.19) then least common type is the chromophobe type (7.31). Our results are consistent with other studies Abdel Hamed M et al [9] and Johnson BA et al [10].

mpMRI includes the following parameter: T2WI SI, in phase opposed phase T1WI, DWI/ADC value and dynamic contrast MRI which includes three phases, first phase obtained at 40 second (cocrticomedullary phase), second phase at the 90 second (nephrographic phase) and third phase at 3 minute (delayed excretory phase).

Regarding T2 WI MRI signal intensity: clear cell RCC(n=24), chromophobe RCC (n=3) and oncocytoma (n=2) all these renal masses (100%) showed moderate to high signal intensity in relation to the renal cortex, regarding papillary RCC (n=5) and lipid poor AML (n=3) all of these masses (100%) showed low SI on T2WI , lipid rich AML(n=4) shows variable signal intensity on T2WI, owing to variable amount of fat content, in which one of these masses (25%) showed high SI on T2WI and three of them (75%) showed isointense SI on T2WI , our results were agreed with many different studies like de Silva S et al [11] and Liu et al [12].

Regarding in phase and opposed phase T1WI sequence: macroscopic fat seen as India ink artefact on opposed phase. Macroscopic fat typically and only present in lipid rich AML (n=4) (100%), and rare in all other types of solid renal masses, these results were agreed with de Silva S et al [11] in which they also found that the macroscopic fat is only present in lipid rich AML, regarding Microscopic fat content seen in opposed phase T1W1 as drop of signal, microscopic fat seen in three masses of clear cell RCC of total number 24 (represent12.5%) , all lipid poor AML (n=3) shows microscopic fat content (100%) , lipid rich AML (n=4) three of these masses (75%) in addition to the Presence of macroscopic fat they also shows presence of microscopic fat content these result were agreed with other studies; Lopes Vendrami et al [13] and Ramamurthy NK et al [4].

Regarding ADC value. At b. value of 800 sec/mm2 that used,

the mean and SD of ADC value for benign lesions was 2.039 ± 0.103 *10-3 mm2/sec, while the mean and SD of ADC value for malignant lesions was 1.507 ± 0.087*10-3mm2/sec and difference between benign and malignant ACD values was statistically significant (P=0.001). The highest mean of ADC value in different subtype of RCC was in clear type (1.64*10-3mm2/sec) and this difference was statistically significant (P=0.001). These results were agreed with Zhang et al [13] study which showed that the differences in ADC values between benign lesions ($2.47 \pm 0.81 * 10^{-3}$ mm^2 / sec) and malignant lesions ($1.81 \pm 0.41* 10^{-3}$ mm^2 / sec) were statistically significant ($P < 0.001$).

Regarding DCE MRI: clear cell RCC (n=24), 23 of these masses (95.9%) showed avid early corticomedullary phase enhancement and washout in the late nephrographic phase (85– 120 second), the remaining one (4.1%) showed plateau type dynamic curve.

All AML (n=7) (both lipid rich and lipid poor) (100%) and all oncocytoma (n=2) (100%) showed early avid corticomedullary phase enhancement and washout in the late nephrographic phase.

chrmomphobe RCC (n=3) showed moderate corticomedullary enhancement and in the late nephrographic phase we notice two of these masses (66.6%) show plateau type dynamic curve on the late nephrographic phase and the third one (33.4%) showed washout type dynamic curve in the late nephrographic phase.

Papillary RCC (n=5) all of them (100%) showed progressive type dynamic and this type of dynamic curve was seen only in this type of solid renal masses, these results were agreed with Heller MT

et al [14], but these results was disagreed with Liu et al [12] study , in which they demonstrate papillary RCC shows two types of dynamic curve (progressive and plateau) also another disagreed result with Liu et al they showed AML demonstrate two types of dynamic curve progressive type dynamic curve and washout type dynamic curve.

The sensitivity, specificity and accuracy of our study was 90%, 96% and 97% respectively in compares to de Silva S et al [11], they found that the sensitivity, specificity and accuracy 96.1%, 85.7% and 93% respectively.

CONCLUSION:

Multiparametric MR imaging, a noninvasive imaging technique, offers vital information that can aid in differentiating the most common solid renal masses. T2WI is important in differentiating between various solid renal mass types and narrowing the differential diagnosis; clear cell RCC, chromophobe RCC, and oncocytoma show moderate to high signal intensity on T2WI; lipid poor AML and papillary RCC show low signal on T2WI; macroscopic fat content is seen as an India ink artefact on opposed phase and seen in lipid rich AML; DWI is crucial in differentiating between benign and malignant solid renal masses, where malignant solid renal masses exhibit diffusion restriction while benign masses show no restriction; DCE MRI is not significant in differentiating between solid renal masses.

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