



Role of the DWI and ADC Value in Complex Renal Cystic Masses (Bosniak III and IV)

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ABSTRACT:

BACKGROUND:

Cystic renal masses are commonly encountered in clinical practice.

OBJECTIVE:

To study the value of diffusion-weighted magnetic resonance imaging (DW-MRI) and ADC value for distinguishing benign and malignant complex renal cystic masses (Bosniak III and IV).

PATIENTS AND METHODS:

The study included 30 patients with complex renal cystic masses identified by computed tomography (CT) and ultrasound (U/S). there was 18 females and 12 males. The study was conducted in Al-Imamain Al-Kadhmain Medical City/ Baghdad from December 2022 to October 2023. The DWI and ADC were correlated with the histological finding (all patients have a histopathological diagnosis by surgical resection).

RESULTS:

The patients' ages ranged from (20-75) years, with mean±SD 56.87±7.07. Most malignant renal cystic masses show restricted diffusion and there was a significant relationship between diffusion restriction and diagnosis of malignant lesions P-value of 0.035. Most of Bosniak category IV were malignant (84.6%) in comparison to Bosniak category III where almost half of the cases (58.8%) were malignant. The ADC value for benign lesions ranged between (0.840–2.510 ×10⁻³mm²/s) and for malignant lesions was (0.530–1.280 ×10⁻³mm²/s) with stastically significant difference (P-value <0.001). The best ADC Cut off - value derived from the analysis was (0.925) with sensitivity and specificity of (88.89% and 90.48%) respectively (lower values were more indicative of malignancy, whereas values above this cut off value, suggested benign lesions).

CONCLUSION:

DWI MRI is highly sensitive and specific for the detection of malignant renal cystic masses. Most malignant renal cystic masses show restricted diffusion and lower ADC value of enhancing septa and solid nodules compared to benign cystic masses. The best cut-off point for ADC value to differentiate malignant from benign renal cystic masses was (0.925) with sensitivity and specificity of (88.89% and 90.48%) respectively.

KEYWORDS: complex renal cystic mass, Bosniak, Diffusion weighted magnetic imaging (DWI), ADC.

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INTRODUCTION:

Cystic renal masses are commonly encountered in clinical practice. In 2019, the Bosniak classification of cystic renal masses, originally developed for CT, underwent a major revision to incorporate MRI and is referred to as the Bosniak Classification, version 2019⁽¹⁾. The proposed changes attempt to (a) define renal masses (i.e., cystic tumors with less than 25% enhancing tissue) to which the classification should be applied; (b) emphasize specificity for the diagnosis of cystic renal cancers, thereby

decreasing the number of benign and indolent cystic masses that are unnecessarily treated or imaged further; (c) improve interobserver agreement by defining imaging features, terms, and classes of cystic renal masses; (d) reduce variation in reported malignancy rates for each of the Bosniak classes; (e) incorporate MRI and to some extent US; and (f) be applicable to all cystic renal masses encountered in clinical practice, including those that had been considered indeterminate with the original classification⁽²⁾.

DWI and ADC in Complex Renal Cysts

Some septa that are less obvious on a CT scan can be seen on an MRI, while cysts that only exhibit equivocal enhancement on a CT scan can show conclusive enhancement on an MRI. As a result, MRI allows for a greater Bosniak classification of renal cysts than CT does⁽³⁾. In comparison to CT, MRI has higher contrast resolution, functional imaging techniques, and no ionizing radiation⁽⁴⁾. In situations where contrast injection is contraindicated, DWI enables identification of cystic renal masses based on the degree of water flow restriction^(5, 6). To evaluate contrast material kinetics inside the solid component of cystic renal masses, indicating the tissue's vascularity, dynamic contrast-enhanced MRI (DCE-MRI) is performed^(7, 8, 9).

AIM OF THE STUDY:

To study the value of diffusion-weighted magnetic resonance imaging and ADC value (MRI) for distinguishing benign and malignant complex renal cystic masses (Bosniak III and IV).

PATIENTS AND METHODS:

This prospective study included 30 patients with complex renal cysts attending the radiology department of AL-Imamain Al-Kadhmain Medical City/Baghdad /Iraq from December 2022 to October 2023. For each patient, the finding obtained using MRI DWI- ADC correlated with the outcome of the histological finding (all patients have a histopathological diagnosis by surgical resection). The 30 patients had previously been identified as having complex renal cystic masses by CT and U/S. The ages of patients ranged from 20-75 years old, 18 females and 12 males. Patients were informed about the examination and an informed consent was taken.

Data collection was done by a specially designed questionnaire and was distributed to all studied patients, the data collected included age, gender, clinical presentation, sociodemographic factors, past medical and surgical history.

Inclusion Criteria: Patients of both genders with Bosniak category III and IV previously identified by contrast-enhanced CT and ultrasound. **Exclusion criteria:** small cysts (<1cm) were excluded from the study due to difficult assessment and to prevent inconsistent measurements on ADC maps, renal cysts that have high signal on T1-weighted images (WI) due to hemorrhagic or high-protein content, Bosniak class I and II renal cysts, Bosniak class 2F cysts without 2-year follow-up, Bosniak class III and IV without histopathological proof and general contraindications to MRI examination.

Ethical Consideration: The study was approved by the scientific committee of the Iraqi Board of Diagnostic Radiology. Verbal informed consent was obtained from all patients included in the study.

MRI examination: MR imaging was performed using a 1.5T MR system (ACHIEVA, Philips medical system/ Netherlands) using a phased array body coil. The patient was examined in the supine position and the total examination time was about 10-15min. All patients were examined with MRI imaging protocol used to assess the complex cystic renal mass and include: Coronal T2 weighted image (TR/ TE 661/80 msec, Flip angle 90° breath-hold, FOV FH (436mm), RL (402mm), AP (189mm), Slice thickness 4mm, Time: 1.54 minutes), Axial T2 weighted turbo spin Echo sequence with fat Suppression (TR/ TE: 587/80 msec, Flip angle 90°, respiratory Triggering, FOV FH (234mm), RL (375mm), AP (297mm), Slice thickness 4mm, Time: 2.21 minute), Axial T1-weighted gradient echo Sequence, in-phase and opposed-phase (TR/ TE: 120/ 2, 3, Flip angle 80°, breath-hold, FOV FH (375mm), RL (264mm), AP (170mm), Slice thickness 5mm, Time: 1.55 minute), Axial diffusion-weighted Sequence (TR/ TE: 13582/ 108 msec, Flip angle 80°, breath-hold, FOV FH (187mm), RL (375mm), AP (305mm), Slice thickness 3mm, Time: 1.55 minute), ADC maps were generated from DWI using commercially available software – work station, and Axial T1-weighted gradient echo: Sequence for dynamic imaging (TR/ TE: 3, 9/ 1, 8, Flip angle 10°, FOV FH (200mm), RL (375mm), AP (297mm), Time: 1.34 minute).

Image Interpretation: The MRI images were interpreted by 2 experienced radiologists. The standard MRI pictures, both contrast-enhanced and unenhanced, were examined first. Every lesion's morphological parameters including location, size, and form, as well as its signal properties and enhancing pattern, were noted. All DWI images were examined collectively, including the ones produced with b values of 0, 600, and 800s/mm². For a b value of 800s/mm², the circumferential region of interest (ROI) was used to measure the ADC values. The ROIs did not include necrotic areas or lesion borders. For every patient at least three measurements were made, and the average was documented. A circular ROIs were positioned in the center of the kidney, which is the normal renal parenchyma.

Criteria of Bosniak III: cystic lesion with thickened irregular wall or measurable enhancing septa >4mm with no solid enhancing nodule.

Criteria of Bosniak IV: Cystic lesion with one

DWI and ADC in Complex Renal Cysts

or more enhancing nodules >4mm. **Benign feature of Bosniak III cyst:** the cyst usually exhibits a reasonably high ADC value and low signal intensity on DWI, much like a typical renal parenchyma. **Malignant feature in Bosniak III cyst:** the cyst may have decreased ADC value in comparison to normal renal parenchyma and higher signal intensity on DWI, especially in any enhancing thick septa. **In Bosniak IV cyst:** the cyst usually exhibits a drastically decreased ADC value of solid nodule and a markedly increased signal intensity on DWI, both of which strongly suggest malignancy. The final diagnosis is confirmed by histopathological diagnosis.

Statistical Analysis was done using Statistical Package for Social Sciences (SPSS) version 22 for Windows. Descriptive statistics are presented as mean \pm standard deviation (SD) and frequencies as percentages. Chi-square and Fisher's exact tests were used for categorical variables when appropriate. T-table's test was used for continuous variables. Sensitivity, specificity, and accuracy were calculated. The P-value of <0.05 was considered statistically significant.

RESULTS:

The study included 30 selected patients with cystic renal masses (Bosniak categories III and IV) were included. In benign cystic renal masses, the age of the patients ranged from (44-71) years, with mean \pm SD 56 \pm 10.25 years, whereas in malignant cystic renal masses, the age ranged from (45 to 73) years, with mean \pm SD 57.24 \pm 5.47 years, with non-statistically significant result; P-value 0.66. Most of the patients were males 22 (73.3%), however; this result was statistically not significant. There were 17 (56.7%) patients with Bosniak category III and 13 (43.3%) patients with Bosniak category IV. The final histopathological diagnoses were 9 (30%) benign masses and 21 (70%) malignant masses.

The longest diameter of cystic renal masses ranged from (2-5) cm, with mean \pm SD 3.83 \pm 0.93mm. The mean diameter \pm SD of both benign and malignant cystic renal masses were 3.5 \pm 0.5 cm for benign lesions and 3.3 \pm 1.08 cm for malignant lesions, this result was not statistically significant.

Regarding MRI diffusion, most malignant renal cystic masses show restricted diffusion and there was significant relationship between diffusion restriction and diagnosis of malignant lesions with a P-value 0.035, as shown in (Table 1).

Table 1: MRI Diffusion in relation to histopathological reports among the patients.

Parameter	Benign		Malignant		P-value
	No.	%	No.	%	
Restricted Diffusion	3	33.3%	16	76.2%	0.035
Non-Restricted Diffusion	6	66.7%	5	23.8%	
Total	9	100%	21	100%	

Regarding the Bosniak category, most of Bosniak category IV were malignant (11 out of 13 (84.6%)) in comparison to Bosniak category III where almost more than half of the cases (58.8%) were malignant, the result was not significant.

Regarding the mean ADC-value for benign lesions was (1.95 $\times 10^{-3}$ mm²/s) ranging between (0.840–2.510 $\times 10^{-3}$ mm²/s) and for malignant lesions was (0.80 $\times 10^{-3}$ mm²/s) ranging between

(0.530–1.280 $\times 10^{-3}$ mm²/s). A significant difference was observed (P-value <0.001) between malignant and benign lesions.

Interpretation of the cystic renal masses and in comparison with the histopathological results for each lesion, there were 8 (88.9%) true benign lesions, and 19 (90.5%) true malignant, one (11.1%) misclassified benign lesions, and two (9.5%) misclassified malignant lesions as shown in (Table 2).

Table 2: Radiological diagnosis in relation to histopathological reports among the patients with cystic renal masses.

Parameters		By Histopathology				P-value
		Benign		Malignant		
		No.	%	No.	%	
Radiological Diagnosis	Benign	8	88.9%	2	9.5%	<0.001
	Malignant	1	11.1%	19	90.5%	
	Total	9	100%	21	100%	

DWI and ADC in Complex Renal Cysts

The ADC- value represented at the ROC curve (Figure 3) and the best ADC Cut off - value derived from the analysis was (0.925) with sensitivity and specificity (88.89% and 90.48%) respectively (lower values were more indicative

of malignancy, whereas values above this cutoff value, suggested of benign lesions) with 80% PPV and 95% NPV. As demonstrated in (Tables 3), the RUC curve is demonstrated in (Figure 1). Figures 2 & 3 show images of some cases.

Table 3: ADC Cutoff value to differentiate between benign and malignant cystic renal masses among the patients.

AUC	P-value	Asymptotic 95% Confidence Interval	
		Lower Bound	Upper Bound
0.931	<0.001*	0.809	1.000
Positive if greater than or equal to		Sensitivity	Specificity
0.7500		88.3	87.4
0.8750		88.1	87.2
0.9250		88.89	90.48
0.9650		77.8	88.16
0.9900		77.8	82.48

*The result was highly significant at p-value <0.001. AUC; area under the curve.

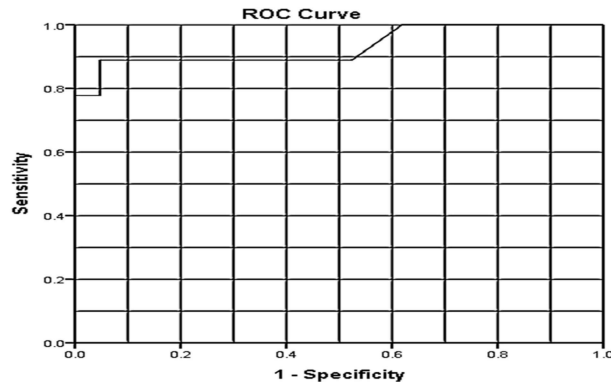


Figure 1: The ADC values at the ROC curve of the cystic renal masses among the patients.

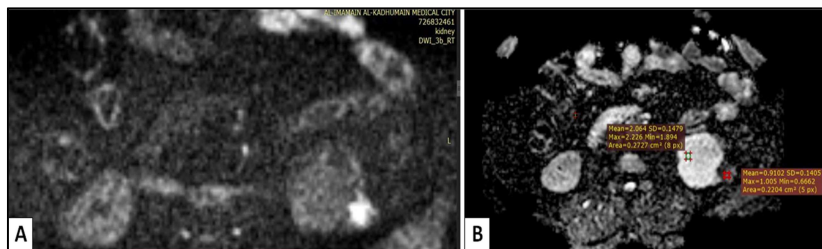


Figure 2: A 60-year-old male patient with Lt. complex cystic renal mass was discovered incidentally by U/S and CT and diagnosis as Bosniak IV in Lt. kidney 4 cm in diameter (A) axial DWI at b value of 800s/mm² and (B) ADC map shows restriction of the solid nodule and the ADC is 0.91 *10⁻³mm²/s. Final diagnosis: after Lt. sided nephrectomy and the pathology revealed clear cell renal cell carcinoma.

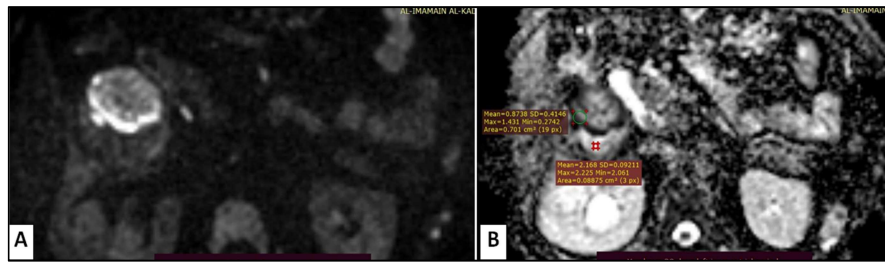


Figure 3: A 68-year-old male patient presented with Rt. loin pain, CT show a complex cystic mass lesion Bosniak III in the Rt. kidney 4 cm in diameter, (A) axial DWI at b value of 800s/mm² and (B) ADC map shows restriction of the thick nodular septation and the ADC is 0.87 *10⁻³mm²/s. Final diagnosis: after Rt. sided nephrectomy and the pathology revealed a renal cell carcinoma (clear cell type).

DISCUSSION:

The Bosniak classification system is a widely used tool in radiology for categorizing the risk of malignancy in cystic renal masses, based on their appearance on imaging⁽¹⁰⁾. DWI can distinguish between benign and malignant cystic masses according to the features of their water diffusion. Because of their higher cellularity and less water movement, malignant lesions usually show restricted diffusion of enhancing thick septa and solid nodules, which lowers their apparent diffusion coefficient (ADC) values on DWI scans⁽¹¹⁾. In the present study the patient’s ages ranged from (44-73) years, with mean±SD 56.87±7.07 years. In benign cystic renal masses, the age of the patients ranged from (44 to 71) years, with mean ±SD 56±10.25 years, whereas in malignant cystic renal masses, the age ranged from (45-73) years, with mean±SD 57.24±5.47 years, with non-statistically significant result; These results were close to that of previously reported studies^(12, 13). In the current study, the mean diameter ±SD of both benign and malignant cystic renal masses was 3.5±0.5 cm for benign lesions and 3.3±1.08 cm for malignant lesions. This result was different from that of Han H et al.⁽¹⁴⁾ study where the mean size of each Bosniak category differed significantly in an increasing manner. GHONEIM et al.⁽¹⁵⁾ study show that MRI with DWI imaging may aid the differentiation of benign from malignant complex cystic renal masses, malignant cystic mass will show restricted enhancing solid nodules and thick septa, the results of the current study was compatible with GHONEIM et al. study regarding MRI diffusion. Another study by ZAKARIA et al.⁽¹⁶⁾ showed that DWI could be utilized in the assessment of the cystic masses detected in the kidneys besides the conventional MR Imaging, which demonstrated that DWI has a significant role in the prediction of the presence

of malignancy in the cystic masses detected in the kidneys. Another study by Inci E et al.⁽¹⁷⁾ showed that DWI has a role in differentiating between benign and malignant renal masses and the malignant enhancing solid nodule shows restriction on DWI. In the present study, mean the ADC value for benign lesions was (1.95 × 10⁻³mm²/s) and for malignant lesions was (0.80×10⁻³mm²/s), A significant difference was observed (P-value <0.001) between malignant and benign lesions. The best ADC Cutoff - value derived from the analysis was (0.925) with sensitivity, and specificity (of 88.89% and 90.48%) respectively similar results were observed by GALMICHE et al.⁽¹⁸⁾ showed that ADC values are low in malignant renal lesions, the mean ADC value of benign (2.2×10⁻³mm²/s) and malignant lesion (0.9×10⁻³mm²/s) and cut-off ADC values of 0.88 × 10⁻³ mm²/s with a sensitivity of 92% and specificity of 93%. Another study by Shaaban et al.⁽¹⁹⁾ showed that the ADC values that are evaluated on DWI are low in solid components of malignant cystic renal masses with mean value (0.96× 10⁻³ mm²/s), in comparison with those that were benign mean ADC value (2×10⁻³ mm²/s) and a Cut-off ADC value of 1.1×10⁻³ mm²/s with a sensitivity of 72.41% and a specificity of 95.74%. Another study by BALYEMEZ et al.⁽²⁰⁾ showed a significant difference in ADC values between benign and malignant complex cystic renal masses with slightly higher value for mean ADC (2.7× 10⁻³ mm²/s for benign and 2.2 x10⁻³ mm²/s for malignant renal lesions masses) and the cut-off point for ADC value to differentiate between benign and malignant cystic renal mass was (< 2.2 × 10⁻³ mm²/s) with sensitivity (75 0.7%) & specificity (92%) this difference in the mean ADC value and cut off value may be attributed that their study was done 3 T MRI scanner and the difference in

inclusion criteria (they include Bosniak IIF in their study). In the present study, regarding the Bosniak category, most of Bosniak category IV were malignant in 11 out of 13 (84.6%) and benign in 2 out of 13 (25.4%) in comparison to Bosniak category III where almost half of the cases (58.8%) were malignant and half of the cases are benign, similar result were observed by Balyemez F et al. study⁽²⁰⁾ showed that most of Bosniak IV were malignant in 9 of 10 (90%) and benign in 1 out of 10 (10%) in comparison to Bosniak category III cysts, 7 out of 12 (58.3%) were malignant and 5 out of 12 (52%) were benign. The most frequent histopathological finding in the current study was clear cell RCC 14 of 30 (46.7%) their result was similar to that of the MOUSSESIAN et al. study⁽²¹⁾ which showed the most histopathological finding was clear cell carcinoma 31 out of 48 (67%).

CONCLUSION:

DWI MRI is a sensitive and specific tool for the detection of malignant renal cystic masses. Most malignant renal cystic masses show restricted diffusion and lower ADC value compared to benign cystic masses. The best cut-off point for ADC value to differentiate malignant from benign renal cystic masses was (0.925) with sensitivity and specificity of (88.89% and 90.48%) respectively (lower values were more indicative of malignancy).

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