Role of multidetector ct in quantitative enhancement- washout analysis of solid renal masses

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Abstract

Background: Enhancement washout technique in solid renal masses using multidetector computed tomography (MDCT) can differentiate different type of lesions. 99 Patients who are presenting with suspected renal masses or renal tumour for staging are included in this study. CT examination are carried out at urology and nephrology centre using MDCT. The attenuation values (Hounsfield Unit) will be assesed for each lesion on the pre enhanced, corticomedullary, nephrographic and delayed phases. Washout ratio will be calculated for each phase of enhancement in comparison to the unenhanced attenuation value. The characteristics of enhancement-washout will be correlated with the final histopathological diagnosis.

Results: Early enhancement and washout pattern was noted in 54 renal lesions (54.5%) representing 4 types of renal lesions; Oncocytoma ($n = 13$), clear cell renal cell carcinoma ($n = 16$), Chromophobe renal cell carcinoma ($n = 15$) and unclassified renal cell carcinoma ($n = 10$).Prolonged enhancement pattern was noted 45 lesions (45.4%); PRCC ($n = 14$), 10 case of lipid poor AML ($n = 10$), metanephric adenoma ($n = 10$) and Xp11 RCC ($n = 11$). High pre-contrast attenuation was noted in Xp 11RCC showing attenuation value 41.7 ± 6.823HU. The highest CMP values were noted in CCRCC (151.9 ± 20.4) followed by oncocytomas (137.6 ± 19.15HU) and then CHRCC (123.6 ± 16.6 HU)while the lowest values were noted in Metanephric adenoma)57.1 ± 17.4HU)and followed by PRCC (59.9 ± 4.8)and followed by lipid poor AML (79.17 ± 13.666) and RCC unclassified (89.06 ± 18.1).

Conclusions: Four-phase MDCT (the unenhanced, corticomedullary, nephrographic, and excretory phases) evaluate role of MDCT in differentiation of solid renal masses.

Keywords: MDCT, CCRCC, PRCC, CHRCC, AML, CMP, NP

Background

A lot of researches study role of MDCT in solid renal masses [1]. From these researches, the imaging criterion in differentiating renal masses is the determination of enhancement [2].A solid enhancing renal mass is highly suspected to be a renal neoplasm. However not all enhancing renal masses represent malignancies, as some benign tumors including; angiomyolipomas (with minimal fat), oncocytomas and rare entities as hemangiomas show stromal enhancement and are to be put in mind [3]. RCC include CCRCC (70%), PRCC (15–20%), and CHRCC (4–6%) RCC [4].A triphasic technique is one of the most important imaging.

A triphasic imaging protocol is composed of non-contrast study in the kidneys and Corticomedullary phase in kidneys and liver (25–70 s after injection), and Nephrogenic phase (80- 180 s). And excretory phase (> 180 s) can help [4].

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Pre enhanced phase establish starting point that enable measurement of enhancement within the lesion [5].

CMP makes 3D reconstructions to evaluate vessels of kidney. also, CMP is important in staging of renal neoplasms [5].

NP is more better in detection and feature of renal lesion as compared to CMP. [6].

The excretory phase helps in delineation of the anatomy of a centrally located lesion [7].

Aim of the study

Evaluate the performance of multi -phase MDCT in characterization of the renal masses, differentiating clear cell RCC from other malignant & benign renal masses on the base of quantitative imaging features.

Methods

Study design and population

99 patients have solid lesions detected by MDCT. All CT examinations were carried out at urology and nephrology center (MUC) using multidetector row helical CT with no age or sex predilection.

Inclusion criteria: Patients who are presenting with suspected renal masses or presenting with renal tumor for staging.

Exclusion criteria: Any medical contra-indication to contrast media or radiation; chronic renal disease, high serum creatinine, pregnancy.

This study was conducted by a qualified staff & our protocol was reviewed and accepted by an institutional review board (IRB) and by the ethical committee of Benha faculty of medicine. Informed consent was obtained from each patient or her relative before enrolling the study.

Patient preparation

Fasting for about 4–6 h before the examination.

Detailed explanation of steps of the study was given to all patients.

Imaging

By 64– detector row scanner, we examinethe kidney; through an un-enhanced scan and multiphasic post contrast phases. CT scans will be performed from the diaphragm to the aortic bifurcation during (CMP). The unenhanced scans and the scans during the nephrographic phase (NP) and the excretort phase (EP) will be performed from the diaphragm to the pelvic floor.

IV nonionic contrast material will be administered at a dose of 2 mL per kilogram of body weight and at a rate of 3 mL/sec to a maximum of 150 mL by using a power injector, or at a slower rate (minimum of 2 mL/sec) if required when venous access will be suboptimal.

Corticomedullary phase measured with ROI (regions of interest) in the abdominal aorta at the level of the celiac trunk. At attenuation of 100 HU, we wait 10 s to reach complete arterial phase scanning, followed by nephrographic phase (delay of 90–110 s), while for the final excretory phase a fixed delay of 240–480 s.

Image study

Image processing and post-processing were performed.

The attenuation values (HU) will be measured for every lesion on pre enhanced and CMP and NP and EP. Wash-out ratio was calculated for each phase of enhancement in comparison to the unenhanced attenuation value. The characteristics of enhancement-washout was be correlated with the final histopathological diagnosis.

In each mass, we take six measurements:

1. 1.MAV in each phase.
2. ΔH [maximum attenuation value in each post contrast phase –maximum attenuation value in precontrast phase]
3. 3.Absolute washout ratio in NP = [(AV at CMP-AV at NP) ÷ (AV at CMP –AV at pre enhanced phase)] X100.
4. 4.Relative washout ratio in NP = [(AV at CMP-AV at NP) ÷ (AV at CMP)] X 100.
5. Absolute washout ratio in EP = [(AV at CMP-AV at EP) ÷ (AV at CMP –AV at pre enhanced phase)] X100.
6. Relative washout ratio in EP = [(AV at CMP-AV at EP) ÷ (AV at CMP)]X 100.

This 6 values compared to final diagnosis after pathology in all cases.

Clinical assessment and final diagnosis

Full history taking and clinical examination was performed by urology specialists in Mansoura University Centre. Final histopathological analysis was done after surgical excision or fine needle biopsy.

Statistical analysis

The P value was considered significant if 0.05 or less at 95% confidence interval. characteristic curve was performed to determine the cutoff point with highest sensitivity and specificity that used to differentiate malignant from benign renal tumors and different subtypes of RCC. The sensitivity, specificity, accuracy, positive predictive value (PPV), negative predictive value (NPV), and the area under the curve was computed from the curve.

Table 1 Size and laterality characteristics of the lesions in the study populations

Tumor characteristics	Diagnoses	
	RCC (*n* = 66)	Benign renal tumors (*n* = 33)
Laterality	No%	No%
Right (*n* = 48)	31 (64.5)	17(35.4)
Left (*n* = 51)	35(68.62)	16(31.37)
Size (in mm)		
Min–Max	13.4–128.0	5.5–146.6
Median	80	55.8

Table 2 Final diagnosis of the lesions and the method of diagnosis

Final diagnoses	Method		
	Excision biopsy	Core biopsy	Clinical and radiological diagnosis
RCC (*n* = 66)	60	6	–
Benign renal tumors (n = 33)	6	5	22
Total (*n* = 99)	66	11	22

Results

The study was performed on 99 cases including 65 males (65.21%) and34 females (34.78%). The mean age is 51.5 ± 12.05 years ranging from 15 to 87 years.

Ninety-nine renal solid masses were detected and analyzed, 66 (66.6%) were malignant, and 33 (33.33%) were benign. Of these, 66 malignant masses; 16 (24.24%) were CCRCCs; 15 (22.72%) were ChRCCs; and 14 (21.21%) were PRCCs and 11 (16.66%) xp11 translocation carcinoma. The 33 benign masses included 13 renal oncocytomas (39.39%) and 10 minimal fat-containing AMLs (30.3%) and 10 metanephric adenoma (30.3).

99 lesions in the study,48 lesions were right sided representing 48.48% and 51 lesions were left sided representing 51.51%. (Table 1). Lesions included in the current study were variable in size; their maximum diameter ranged from 5.5 to 146.6 mm. (Table 1).

The final diagnosis has been reached by excision biopsy in 66 lesions (66.6%), core biopsy in 11 lesions (13.4%), in the remaining 22 lesions (22.2%) the diagnosis was based on the radiological findings supported by clinical data (Table 2).

Renal lesions were divided into two groups according to their enhancement dynamics,first group (*n* = 54) included those showing early enhancement followed by wash out pattern of enhancement and the second group included the other lesions (*n* = 45) including lesions with prolonged enhancement pattern. Significant difference regarding the degree of enhancement between the two groups in the CMP ($P < 0.0001$) and NP ($P < 0.0001$) and EP (P = 0.004) (Table 3.

Estimated attenuation values (by HU) for both groups were 126.3 ± 28.8, 97.9 ± 21.8 and 69.2 ± 17.3 versus 69.4 ± 18.4, 72.8 ± 18.7 and 57.4 ± 13.3 for the 1st and 2nd groups respectively, (Table 5).

Xp 11 translocation RCC showed significantly higher CT attenuation than other RCC subtypes 41.7 ± 6.823HU versus34.3 ± 5.1HU ($P < 0.001^*$).

Early enhancement with wash out enhancement pattern was seen in 54 out of 99 renal lesions (54.5%)0.13 case Oncocytoma, 16 case of CCRCC, 15 case of CHRCC and10 case of unclassified RCC.

Table 3 Post contrast CT parameters (attenuation value) among solid renal lesion (*n* = 99)

CT parameters	Lesions		Test of Significance
	Rapid washout *n* = 54	Prolonged *n* = 45	
CMP			
Attenuation			t = 15.8 *P* < 0.0001*
Min–Max	62.2–169.6	39.9–92.0	
Mean ± SD	126.3 ± 28.8	69.4 ± 18.4	
NP			
Attenuation			t = 4.4 P = < 0.0001*
Min–Max	52.2–141.4	56.6–138.2	
Mean ± SD	97.9 ± 21.8	72.8 ± 18.7	
EP			
Attenuation			t = 2.7 P = 0.004*
Min–Max	44–108	32.1–91.0	
Mean ± SD	69.2 ± 17.3	57.4 ± 13.3	

*significant at $P \leq 0.05$

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Table 4 Comparison betwean PRCC and Non PRCC in enhanced phase

Parameter	Lesions		Significance
	PRCC $n=14$	Non PRCC $n=52$	
CM Mean $\pm$ SD	59.9 $\pm$ 4.8	112.5 $\pm$ 35.2	t = 5.5 $P<0.0001*$
Nephrogenic Mean $\pm$ SD	81.2 $\pm$ 5.04	94.7 $\pm$ 21.5	t = 2.2 p = 0.02*
Excretory Mean $\pm$ SD	63.9 $\pm$ 4.6	72.3 $\pm$ 15.3	t = 2.02 p = 0.04*

*significant at $P \leq 0.05$

Another pattern of enhancement included prolonged enhancement that was noted in the rest of renal lesions with the lowest degrees of enhancement were noted in14 case PRCC, 11 cases of XP11RCC, 10 cases of Angiomyolipoma and 10 case of Metanephric adenoma. This feature differentiated the 4 previously mentioned lesions from CCRCC and CHRCC.

PRCC showed significantly lower CT enhancement than other RCC subtypes (Table 4).

Oncocytoma showed the highest attenuation value in nephrogenic phase in first group.

The mean enhancement of CCRCCs was significantly greater than that of oncocytomas in the corticomedullary phase (151.9 vs 137.6 HU, $P<0.0001$).

The mean enhancement of oncocytomas was significantly greater than clear cell renal cell carcinomas in both nephrographic and excretory phase (114.1 HU vs 100.9 HU, P = 0.02*) and (84.6 HU vs 66.9 HU, $P<0.0001*$) (Table 5).

In contrast to clear cell RCCs and oncocytomas,The peak of enhancement of PRCC is in nephrographic phase (Table 5).

The mean enhancement of CCRCCs was significantly greater than that of PRCCs in the CMP (151.9 $\pm$ 20.4 HU vs 59.9 $\pm$ 4.8 HU, $P<0.0001$), nephrographic (100.9 $\pm$ 15.15 HU vs 69.5 $\pm$ 21.7 HU, $P<0.0001$), and excretory (66.9 $\pm$ 15.2 HU vs 54.4 $\pm$ 15.6 HU, $P<0.0001$) phases (Table 5).

ΔH helped to discriminate the first group as clear cell RCCand chromophobe RCCs from the second group papillary RCC and other benign lesion with a sensitivity of 95% (94 of 99 cases) a Specificity of 75% (74 of 99 cases) and a positive predictive value of 94.2%%% (93 of 99 cases), and a negative predictive value of 96% (95 of 99 cases) (Table 6).

Threshold levels of 80 HU in the Nephrogenic_phase differentiate between the first group as clear cell RCCand chromophobe RCCs from the second group papillary RCC and other benign lesion with a high sensitivity of 77% (76 of 99 cases), low specificity of 46%(45 of 99 cases) and, a positive predictive value of 70.7% (70 of 99 cases), and a negative predictive value of 100% (99 of 99 cases) (Table 6).

Table 5 Attenuation values of different solid renal lesions ($n=99$) at various post contrast phases

Pattern of enhancement	Attenuation value	Attenuation (HU)		
		CMP	NP	EP
Wash out pattern ($n=54$)	CCRCC ($N=16$)	151.9 $\pm$ 20.4	100.9 $\pm$ 15.15	66.9 $\pm$ 15.2
	Oncocytoma ($N=13$)	137.6 $\pm$ 19.15	113.3 $\pm$ 17.75	84.6 $\pm$ 14.7
	RCC unclassified ($n=10$)	89.06 $\pm$ 18.1	74.8 $\pm$ 14.2	56.4 $\pm$ 18.8
	CHRCC ($n=15$)	123.6 $\pm$ 16.6	93.6 $\pm$ 17.8	59.7 $\pm$ 8.9
Prolonged enhancement pattern ($n=45$)	PRCC ($N=14$)	59.9 $\pm$ 4.8	69.5 $\pm$ 21.7	54.4 $\pm$ 15.6
	Lipid poor AML ($n=10$)	79.2 $\pm$ 13.6	72.4 $\pm$ 12.07	60.03 $\pm$ 6.5
	Metanephric adenoma ($n=10$)	57.1 $\pm$ 17.4	91.2 $\pm$ 11.5	62.25 $\pm$ 11.6
	Xp11 RCC (11)	91.05 $\pm$ 21.2	100.7 $\pm$ 22.3	80.5 $\pm$ 20.02

Table 6 Cutoff value differentiation between CRCC/CHRCC from other types

Test result variable (s)	AUC	SE	Asymptotic 95% confidence Interval	Cutoff value	Validity	
					Sensitivity	Specificity
CM_phase	0.955	.027	0.903–1.008	95	0.95	0.82
Arterial ΔH	0.970	.020	.932–1.009	65	0.95	0.75
Nephrogenic_phase	0.826	.057	.713–0.93	75	0.77	0.46
Excretory_phase	0.48	0.06	0.36–0.59	58	0.74	0.27

16% and 5% which is a Cutoff points value of absolute and relative washout nephrogenic which have a sensitivity 85% and 81%,a specificity 75% and 83%, in discriminating CCRCCs and ChRCCs from PRCCs and benign lesions (Table 7).

14% and 30.5% is a Cutoff points value of absolute and relative washout excretory which were found to have a sensitivity 85% and 100%,a specificity 72% and 82% in discriminating CCRCCs and ChRCCs from PRCCs and benign lesions (Table 7).

Table 8 contains the listed +ve and −ve predictive value of cutoff points of absolute washout nephrogenic,relative washout nephrogenic and absolute washout excretory and relative washout excretory and CMP and ΔH and nephrogenic and excretory phase.

Discussion

In the current study, assessment of renal masses by non-contrast CT, XP11 translocation carcinoma ($n=11$) (Fig. 1) had the highest pre contrast attenuation values than other RCC sub types ($n=55$) (41.7 ± 6.8 versus 34.3 ± 5.1HU with $P < 0.001$). the same result by Sungmin et al. [8] found that CT high pre contrast attenuation in tumors correlated with Xp 11, while Wang et al. [9] found Xp 11 mildly hyperdense on unenhanced CT than other lesion (Fig. 1).

Lipid-poor angiomyolipoma (AML) ($n=10$) came second in high pre-contrast attenuation value (38.18 ± 4.36 HU). These results agree with Kim et al. [10] who found that 53% of AMLs (containing minimal fat) had high attenuation, in the same-study about 22% of RCCs (regardless their subtype) had also high attenuation on unenhanced scans. In other studies [11–13] lipid poor AMLs showed high pre contrast attenuation.

AMLs with minimal fat may have undetectable fat on CT. This makes them hard to differentiate from RCCs [10]. All cases of angiomyolipoma (10/10- 100%) in our study have had minimal fat (lipid poor angiomyolipoma) [14].

Papillary RCC (Fig. 2) shows third high pre-contrast attenuation value ($n=14$) (35.47 ± 4.23 versus 28.8 ± 3.8 with P = 0.02), same results were found by El-Esawy et al. [15] and Fujimoto et al. [16] and Chen et al. [17] who found that CT high attenuation in tumors has been shown to correlate with PRCC.

Based on the current study data in assessment of the enhancement pattern and the degree of enhancement:

The renal tumors can be classified into two groups; The 1st group included the lesions that enhanced avidly in the corticomedullary phase (CMP) with wash out in the following phases ($n=54$). This group included four tumor types which were CCRCC (Fig. 3)and CHRCC (Fig. 4) and RCC unclassified, oncocytoma. The 2nd group included the remaining solid renal lesions ($n=45$) including PRCC and Lipid poor AML, Metanephric adenoma,Xp11 RCC these lesions showed lower degree of enhancement with prolonged enhancement pattern. Through measurement of the post contrast attenuation value in various post contrast phases, the 1st group showed significantly higher values than the second group at the CMP ($P < 0.0001$) and nephrographic phase ($P < 0.0001$using attenuation value) and excretory phase (EP) (P = 0.004 using attenuation value) (Table 3).

Zehang et al. [18] found in their study over 193 patients with renal tumors that CCRCCs and oncocytomas enhanced strongly in CMP, whereas CHRCC and lipid-poor AML enhanced intermediatly and PRCC enhanced the least.

In the current study, multi-phasic contrast enhanced CT was able to differentiate between RCC subtypes and other masses through the pattern and degree of enhancement at different phases. The CCRCC (Fig. 3) showed the highest enhancement at CMP ($n=16$) (151.9 ± 20.4) Oncocytoma ($n=13$) (137.5 ± 19.15) followed by followed by CHRCC lesions ($n=15$)(123.6 ± 16.6HU) then Xp11 RCC ($n=11$) (91.1 ± 29.09HU)then unclassified RCC ($n=10$) (89.06 ± 18.1) and PRCC ($n=14$) (59.9 ± 4.8). followed by Metanephric adenoma ($n=10$) which showed the lowest values (57.1 ± 17.4) (Table 5).

Attenuation value of CCRCC was much higher than PRCC in the CMP and NP and EP.

Chai Jung et al. [19] found that the CCRCC differ in enhancement from prcc significally in corticomedullary phase and differ in enhancement significally in nephrogenic phase from non-clear cell types.

In other studies, Kim et al. [14]found that the mean enhancement of CCRCC is 149 HU ± 46, however the mean enhancement of PRCC is 91 HU ± 12 and CHRCC enhanced to 90 ± 14 while Wang et al. [20]

Table 7 Predictive value of CT wash out levels for CUTOFF points (diagnostic to CCRRC&ChRCC)

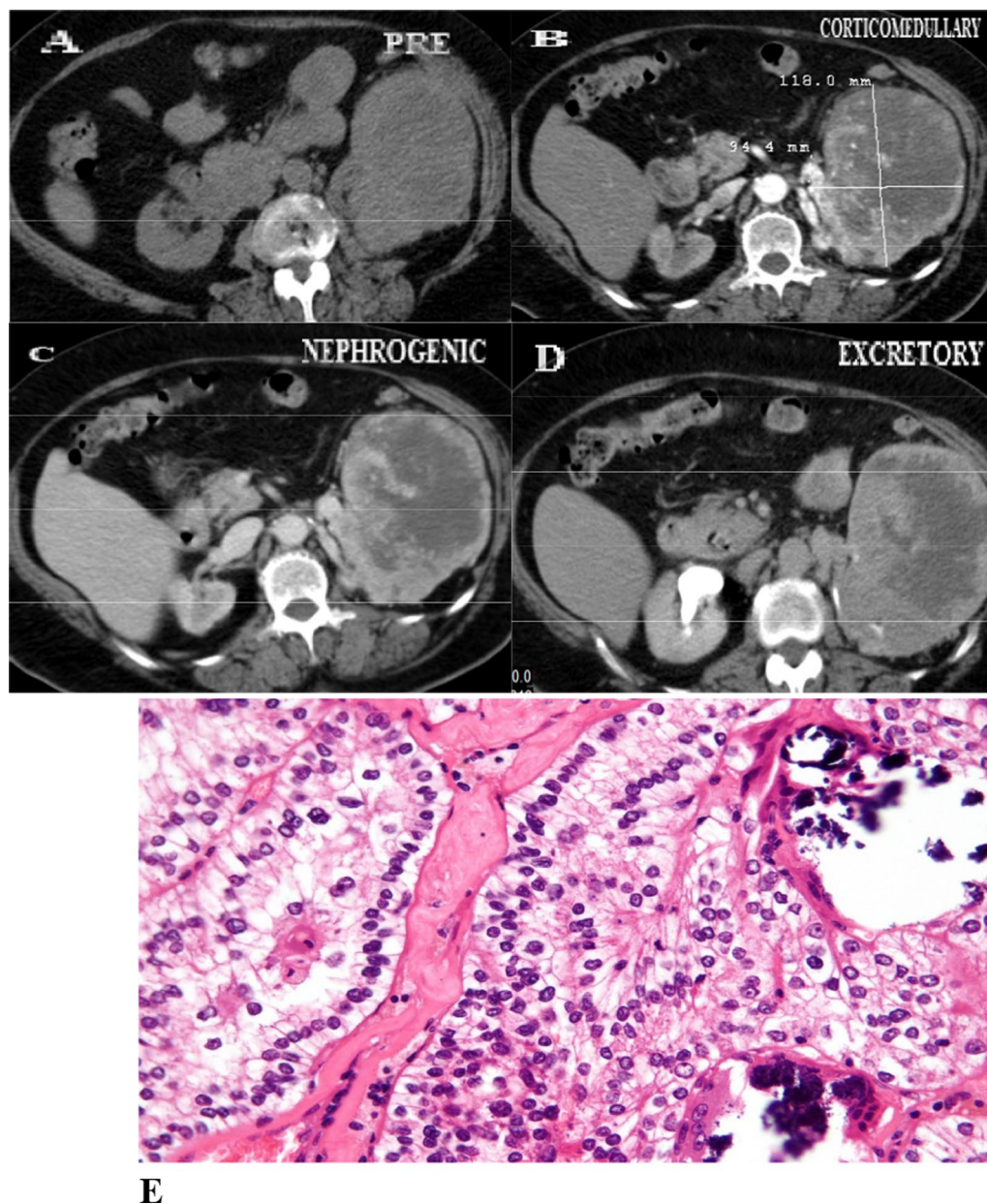|	PPV (%)	NPV (%)
Absolute washout nephrogenic	95.6	87.6
Absolute washout excretory	96	90
Relative washout nephrogenic	95	87.05
Relative washout excretory	91.7	88.46
CM	96.6	100
ΔH	94.2	96
Nephrogenic	70.7	100
Excretory	77.14	72

Fig. 1 XP11 translocation renal cell carcinoma. 39-year-old woman with left loin pain. Shows large 11 × 9 cm left homogenous mildly hyperattenuating renal mass with mean attenuation (41 HU) in pre enhanced phase (**A**) with large necrotic portion and Posterior solid component mean attenuation value of the lesion 91 HU in the corticomedullary phase (**B**).100 HU in the nephrographic phase (**C**) 80HU in the delayed phase (**D**). Histopathological diagnosis: xp11 RCC (Image **E**)

found that papillary subtype differ from the clear cell subtype in enhancement is due to differences in the vascularity due to micro-vessel density.

In our study 8 out of 10 (lipid poor type) showed prolonged enhancement pattern with arterial phase attenuation of 79.2 ± 13.6. Kim et al. [14] found the matching results as 58% of the AML in their study showed prolonged enhancement pattern.

We used three phases of contrast enhancement in our study (coticomedullary phase, nephrogenic, excretory phases), also pre-enhanced phase is used.
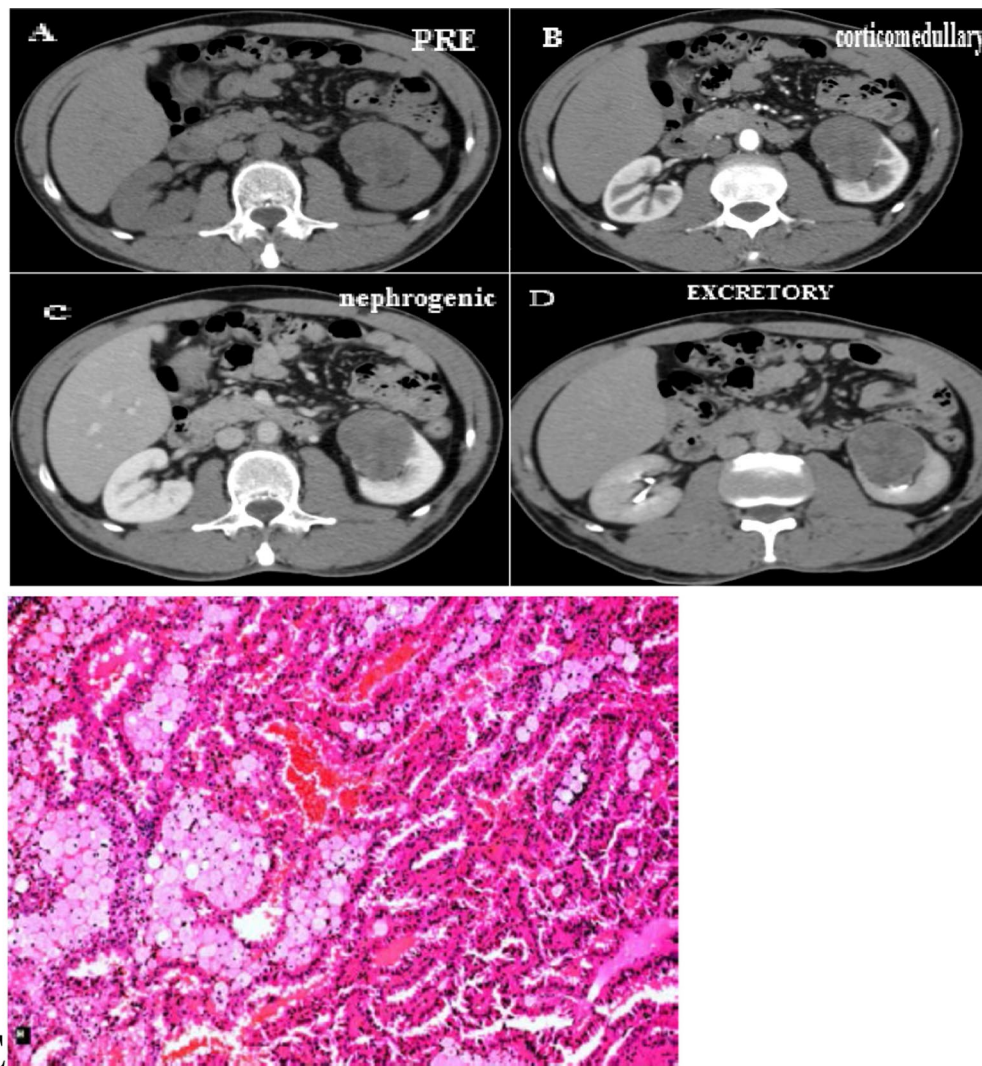
Fig. 2 Papillary cell renal cell carcinoma. A 35-year old female patient presented with left loin pain. Pre enhanced scan (**A**) shows large 12 × 10 cm left renal mass mid pole homogenous mildly hyperattenuating mass with mean attenuation (35 HU).Homogenous mild enhancement with mean attenuation value of the lesion is 56 HU in the corticomedullary phase (**B**). 69 HU In the nephrographic phase (**C**). 54 HU in the delayed phase (**D**). Histopathological diagnosis: papillary RCC (Image **E**)

Two post contrast phases are used to differentiate between renal masses some studies used the CMP and NP [21]. OTHER utilized CMP and EP [22, 23], also some auther used the nephrogenic and excretory phases in differentiation [23].

If MAV in the CMP is 95 HUs or more,it could predict clear cell renal cell carcinoma or chromophobe renal cell carcinoma with high sensitivity and specificity and greater than 95% and 82%.

ΔH is 65 HUs or more Could predict clear cell renal cell carcinoma or chromophobe renal cell carcinoma with high sensitivity and specificity and greater than 95% and 75%.

Choi J H et al. [24]found higher mean HU values of nephrogenic phase were highly predictive of renal oncocytoma as there is significant difference in enhancement between renal oncocytoma and RCC in nephrogenic phase ($P < 0.001$) [24].

One auther found rapid washout in clear cell RCC which differentiate it from other renal masses [24]. Some authors did not observe this rapid washout in CCRCC because their protocol containing only pre-enhanced, nephrographic, and excretory phases, excluding the corticomedullary phase, which is essential in differentiating solid renal masses in our and other study [16, 25]. Our results suggest that high
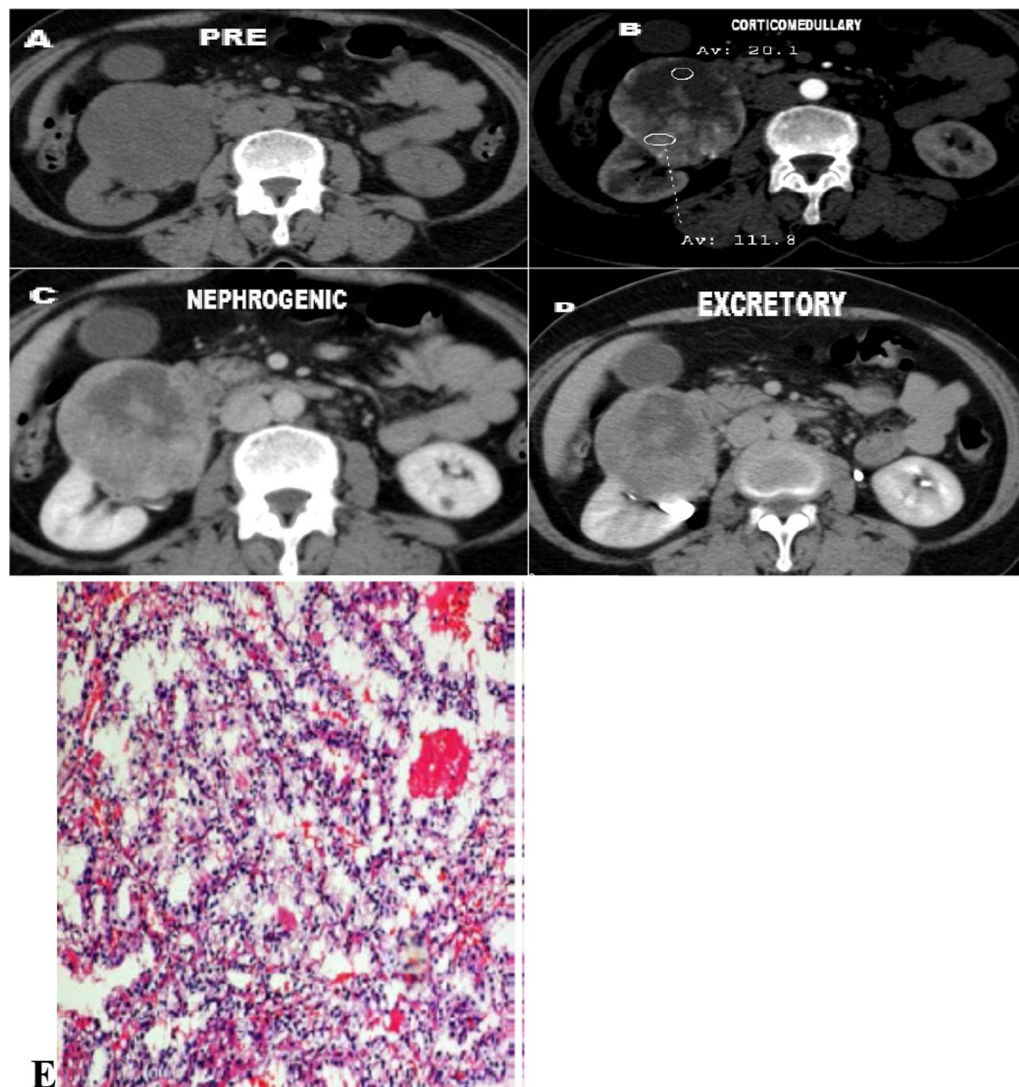
Fig. 3 CCRCC. A 53-year old male patient presented with haematuria. -Pre enhanced scan (**A**) shows right renal large heterogeneous mass, mean attenuation (32 HU) in pre enhanced phase, 151 HU in the corticomedullary phase (**B**).105 HU in the nephrographic phase (**C**). 60 HU in the excretory phase (D). Quantitative findings indicate the high likelihood of the Clear subtypes RCCs. Patient underwent open total nephrectomy. Histopathological diagnosis: High grade Clear cell renal cell carcinoma (Image **E**)

corticomedullary attenuation in a lesion suggest clear cell RCC than an oncocytoma, while biopsy [26], still necessary to differentiate them.

Smaller values of MAV or ΔH is more likely with diagnosis of PRCCs and XP11RCC and benign lesions.

Nephrogenic and excretory phases have a high cutoff point with high positive and negative predictive value in discriminating the 2 groups (CCRCCs and ChRCCs) from PRCCs and xp11RCC and benign lesions. This is due to they do not show significant washout in NP. This pattern of washout explain significance of incorporation corticomedullary and nephrogenic and excretory phases in our study.

Excretory phase differentiate significally PRCCs from benign lesions. Where PRCCs show a slow washout in most of cases, delayed enhancement in EP with higher attenuation values than the prior phases. The characteristic pattern of enhancement observed in papillary renal cell carcinoma, however benign masses showed considerable washout (P ≤ 0.05). Thus, using excretory phase is important in differentiation malignant renal masses from benign by measuring washout of the contrast.

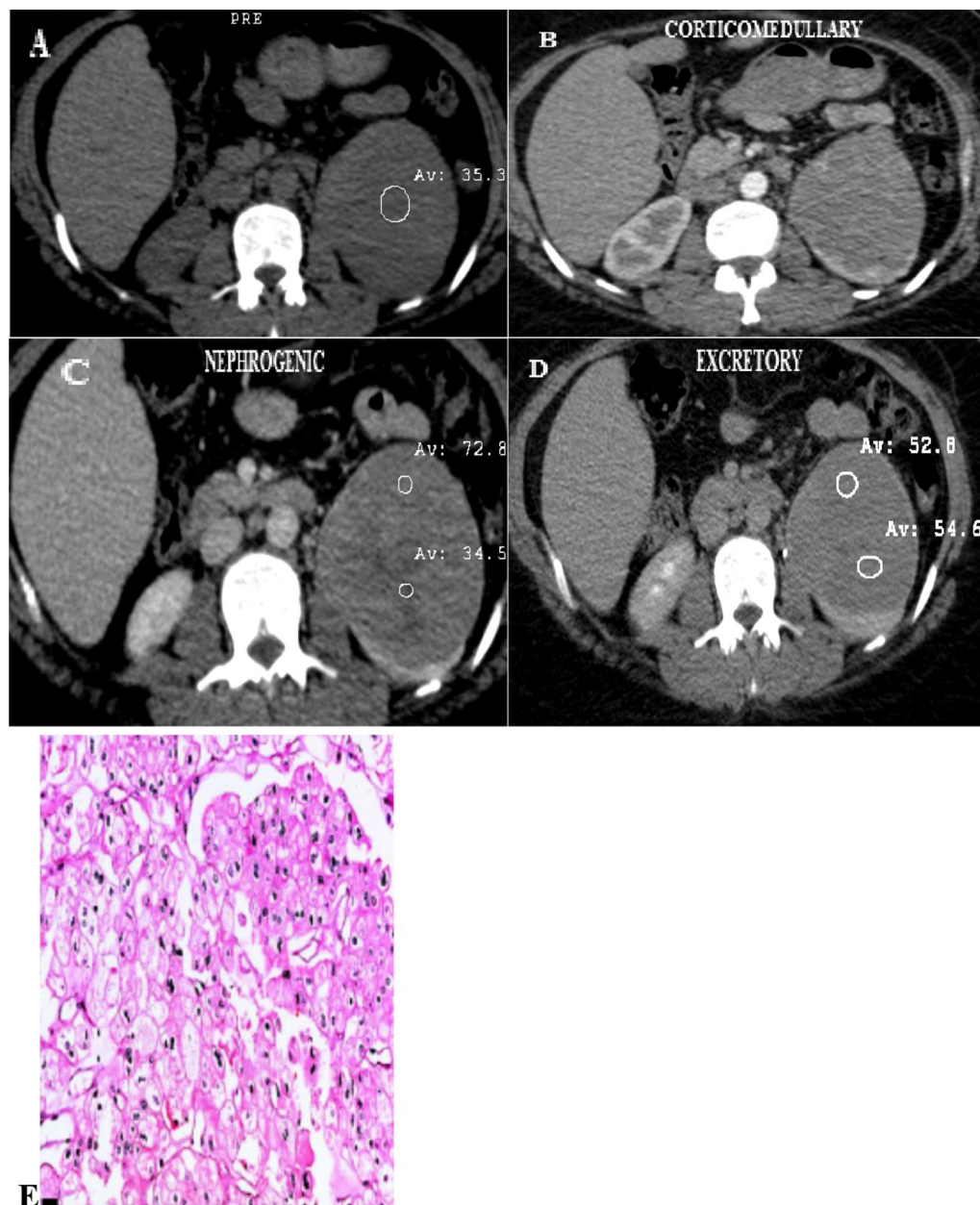**Fig. 4** Chromophobe RCC. A 46-year old male patient presented with left loin pain. o Pre enhanced scan (**A**) shows left renal large heterogeneous mass, mean attenuation (35 HU). The mean attenuation value of the lesion is 123 HU in the corticomedullary phase (**B**), 93 HU In the nephrographic phase (**C**), 54 HU in the excretory phase (**D**). Quantitative findings indicate the high likelihood of the non-Clear subtypes RCCs. Patient underwent open total nephrectomy. Histopathological diagnosis: Chromophobe renal cell carcinoma (Image **E**)

Our results ensure that using three phases of post contrast is important in differentiation of different renal masses in addition to the precontrast phase.

Our result found that combination of pre enhanced phase and CMP can predict lipid poor angiomyolipo- mas …..hyperdense unenhanced attenuation greater than 45 HU renal mass that shows homogeneous peak attenuation in the corticomedullary phase is more likely to be lipid-poor angiomyolipoma.

The hyperdense lipid-poor angiomyolipoma has been explained in several researches [14, 27, 28], most recently by Yang et al. [1], who said that pre-enhanced high atten- uation was the only parameter signify differentiation between lipid-poor angiomyolipoma and clear cell RCC.

In our study, CCRCC and ChRCCs was Characterized from PRCCs and benign renal masses on principle of attenuation value more than 95 in the CMP with sensitivity of 95%, specificity of 82%, PPV of 96%, and NPV of 100%.

Our quantitative results showed that Arterial ΔH (MAV with tissue enhancement in arterial phase—MAV in the unenhanced scan) greater than 65 has sensitivity of 95%, specificity of 75%, PPV of 94%, and NPV of 96% used quantitative parameters to differentiating CCRCC,ChRCCs from PRCCs, benign renal masses, Other masses with lower MAV or ΔH will be suggestive of PRCCs and benign lesions.

Absolute washout nephrogenic and relative washout nephrogenic cutoff points (16% and 5%)were revealed a sensitivity and specificity of 85% and 75%, and 81% and 83% in characterization CCRCC and CHRCC from PRCC and benign lesions.

Absolute washout excretory and relative washout excretory cutoff points (14% and 30%) were revealed a sensitivity and specificity of 85% and 100%, and 72% and 82% in characterization clear cell renal cell carcinoma and chromophobe renal cell carcinomas from papillary renal cell carcinoma and benign lesions.

Table 7 contains The PPV and NPV of each cutoff point.

My research is unique because of large number of cases and different type of lesion and complete quantitative analysis of each lesion.

Our study has many restrictions. Its prospective planning may introduce improper randomization. Our specialized hospital in which patients may have a higher incidence of malignancy in contrast to general population. We involved renal lesion which were proven pathologically with biopsy, which may be source of error. Second, we didn't include the tumor staging system in our study.

Conclusions

MDCT play a significant role by multiphasic renal mass attenuation values (pre-enhanced,corticomedullary,nephrographic,and excretory phases) in differentiation of solid renal masses.

Abbreviations

MDCT: Multidetector computed tomography; CCRCC: Clear cell renal cell carcinoma; PRCC: Papillary cell renal cell carcinoma; CHRCC: Chromophobe renal cell carcinoma; AML: Angiomyolipoma; CMP: Corticomedullary phase; NP: Nephrogenic phase; EP: Excretory phase.

Authors' contributions

SHAG and HMF and MMR and TAE carried out the work. TAE designed the study, HMF and TAE collected the patients and gathered the data, SHAG and MMR and TAE collected and reported the radiological data. SHAG and HMF did the statistical analysis and was responsible for collecting the scientific data and writing the manuscript. All authors read and approved the final version to be published.

Availability of data and materials

All data and material of the article are readily available.

Declarations

Ethics approval and consent to participate

The authors obtained permission to conduct this study and was approved by Research Ethic Committee (REC) at faculty of medicine banha University; Banha, Egypt (number 20113RAD).. all participants gave written informed consent. The procedures followed were in accordance with our protocol.

Consent for publication

All participants gave written informed consent.

Competing interests

The authors declare that they have no competing interests.

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