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ROLE OF MULTIDETECTOR CT IN CHARACTERIZATION OF RENAL MASSES WITH HISTOPATHOLOGY AS GOLD STANDARD

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Abstract

Objective: *To determine the diagnostic accuracy of multidetector computed tomography (MDCT) in characterization of renal masses with histopathology as gold standard.*

Study Design: *Cross sectional validation study.*

Study Setting: *This study was conducted at the Department of Diagnostic Radiology, Shifa International Hospital, Islamabad*

Study Duration: *Six Months (August 24 to January '25).*

Methodology: *140 patients with suspected renal masses either clinically or on ultrasound who proceeded with computed tomography (CT) scan as well as biopsy were included in the study. After taking informed consent, data was collected prospectively. Histopathology reports of all the patients were followed. A 2 x2 two table was constructed for positive/negative malignant renal masses on CT versus histopathology. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated.*

Results: *MDCT had Sensitivity of 98.3%, specificity of 81.8%, and positive predictive value of 96.6%, negative predictive value of 90.0% while diagnostic accuracy of 95.7% in detecting renal masses. Most common type of malignancy in our study population was renal cell carcinoma (RCC) seen in 83.8 % of the patients. Clear cell type of RCC was the most common seen in 85 (74.6 %) patients. Fumarate hydratase deficient was the least common subtype of RCC seen in 1 (0.9%) patient.*

Conclusion: *MDCT is an excellent diagnostic tool in characterization of renal masses and can replace invasive procedures like biopsy or nephrectomies when not required.*

Keywords: MDCT, Renal Mass, RCC, Diagnostic radiology, Diagnostic Accuracy,

INTRODUCTION

Renal cell carcinomas (RCCs), which come from the renal cortex, are responsible for 80 to 85 percent of all primary renal neoplasms. Transitional cell carcinomas, which infiltrate the renal pelvis, make for around 8% of all cancer cases.[1] Oncocytomas, collecting duct tumors, angiomyolipomas, and renal sarcomas are examples of other uncommon parenchymal epithelial malignancies. Wilms tumors and nephroblastoma are common in kids. [2] Patients with sickle cell disease may develop medullary renal carcinoma, a rare but serious form of renal cell carcinoma. The most frequent kind of RCC is clear cell, however papillary and chromophobe tumors are less common subtypes.[3]

The exact etiology of RCC is unknown. An individual's risk for kidney cancer is increased by the following factors: African American ethnicity, sickle cell disease, chronic renal failure, obesity, hypertension, dialysis, polycystic kidney disease, and renal stones.[4]

When RCC is suspected, renal and bladder ultrasonography is usually the first radiographic test. If the renal ultrasound shows a solid mass or a complicated cyst with septations or nodules, a dedicated CT scan of the kidneys, ureters, and bladder should be done both before and after IV contrast. If this happens, delayed imaging of the whole abdomen and pelvis should also be done.[5]

A computed tomography (CT) scan before and after IV contrast should be performed if the renal ultrasound is negative but the patient has unexplained hematuria. This is because small solid renal masses and small renal stones can be readily overlooked on ultrasound.5 Clear cell RCC will usually show a considerable enhancement on a CT scan, usually more than 20 Hounsfield units (HU) after administration of intravenous contrast agent. Renal carcinoma postcontrast HU typically measures around 141 HU. Papillary and chromophobe subtypes may not be as enhancing as clear cell RCC.[6]

A study conducted by Jae Heon Kim and Hwa Yeon Sun found that CT's sensitivity and specificity for identifying renal masses were 79.7% and 44.4%, respectively, with a 30% prevalence of malignant renal masses. [7] Another study found a sensitivity of 96%, a specificity of 80%, and a prevalence of 30%. [8]

A CT scan, which is usually a one-step test, can give you most of the information you need about the size and location of the lesion, perinephric dissemination, venous involvement, degree of adenopathy, infiltration of nearby organs, and distant blood-borne metastases. This study will assess the role of MDCT in the characterisation of renal masses to generate additional evidence.

METHODOLOGY:

The study was a cross-sectional validation conducted at the Department of Diagnostic Radiology at Shifa International Hospital, Islamabad, for a duration of six months from August'24 to January'25, after getting permission from the Institutional Review Board (IRB# 118-23, dated: 04-apr-2023). We used a sensitivity and specificity calculator to figure out the sample size. Using a sensitivity of 96% and a specificity of 80%, a prevalence of 30%, an absolute precision of 10, and a confidence The sample size was n = 140, with a 95% confidence interval. We employed a non-probability consecutive sampling method. The study covered all patents aged 30 to 65 years, both male and female, with suspected renal mass. A suspected renal tumor was characterized as a partially cystic or solid mass observed by ultrasonography. Individuals exhibiting negative ultrasonography results for a mass yet presenting with clinically unexplained hematuria were also incorporated. Patients having a history of renal surgery, pregnancy, allergy to intravenous contrast agents, chronic kidney disease (creatinine >1.5 mg/dl), and those who did not have biopsy or nephrectomy were excluded from the research. After getting informed consent from the participants, data was collected in a forward-looking way. First, demographic information such as age, medical record number, and gender were collected.

The protocols were followed when Multidetector Computed Tomography (MDCT) was done with a 128-slice multidetector scanner. Patients were lying on their backs on the couch. To begin with, the technicians took a picture of the abdomen as a scout. A low-dose plain non-contrast computed tomography (NCCT) of the kidney and urine bladder (KUB) area was done at 250 MAS and 80 KV. After injecting 80–120 ml of non-ionic contrast solution (iohexol)

with 300 mg/ml of iodine into a vein, slices were taken with a collimation of 640 x 625, a pitch of 0.765, a 5 mm increment, a 5 mm thickness, at 300 MAS and 120 After that, at least two radiologists looked at the pictures in the sagittal, coronal, and axial planes. We kept an eye on all of the patients who went on to get a biopsy or nephrectomy. There was a link between the histological results and the CT scan data.

A malignant renal mass on CT was characterized as: 1) a solid lesion over 3 cm in size, exhibiting a central scar or post-contrast enhancement, or 2) A mass that comes from the renal pelvis and shows problems in the collecting system during the excretory phase, like calyceal dilatation, tumor-distended calyces, or a filling deficit in the calyces because of tumor infiltration or 3) A number of poorly enhancing masses, with or without nephromegaly, or 4) A cystic lesion characterized by thicker, irregular septa exhibiting visible enhancement (Bosniak classification III) or distinct enhancing soft tissue nodules (Bosniak classification IV). Histopathology defined a malignant renal mass as: 1) Vacuolated, fluffy, or granular cytoplasm in tumor cells, which usually have indistinct cell boundaries (chromophobe renal cell carcinoma has clear borders); 2) Variable atypia, uneven outlines, haphazard orientation with aberrant chromatin, and nucleoli in tumor nuclei that are not always visible. 3) Hemosiderin deposits, small cytoplasmic vacuoles, and a diverse cell population (key features for distinguishing from other neoplasms). Malignant renal masses identified via CT and histology, regardless of positivity or negativity, were documented on a specifically prepared proforma.

Data entry and analysis were done with IBM-SPSS version 26. We calculated the mean ± standard deviation for quantitative variables like age. We calculated the frequencies and percentages of qualitative data such gender, presenting complaints, diagnosis, subtype of RCC, and whether the malignant renal mass was positive or negative on CT and histology. We used the 2X2 model and MedCalc software to figure out how sensitive, specific, positive predictive, negative predictive, and accurate CT was compared to histology.

RESULTS:

The mean age of participants was 55.7 ± 13.1 years. There were 98 (70%) male participants while 42 (30) % female participants. Most common presenting complaint was pain in the abdomen seen in 48 (34.3%) cases while renal lesion was an incidental finding in 40 (28.6%) cases. Nonspecific symptoms like fever and weight loss were seen in 6 (4.3%) the patients. 16 (11.4%) patients presented with lower urinary tract symptoms. The most common diagnosis was RCC seen in 114 (81.4%) cases followed by renal cysts seen in 17 (12.1%) cases. Less common diagnoses were transitional cell carcinoma (TCC), oncocytoma, tuberculosis and adult cystic nephroma. The most common sub type of RCC was clear cell seen in 85 (74.6%) cases while least common type was fumarate hydratase deficient seen in 1 (0.9%) patient as shown in table# I.

Table # II shows cross tabulation of malignant renal mass on CT vs malignant renal mass on histopathology. Multidectetor CT had Sensitivity of 98.3%, specificity of 81.8%, positive predictive value of 96.6%, negative predictive value of 90.0% while diagnostic accuracy of 95.7% in detecting renal masses as shown in Table # III.

Figure IA shows a biopsy proven case of clear cell RCC, while figure IB shows case of oncoytoma which was indistinguishable from RCC on imaging. Figure IIA and IIB show biopsy proven case of TCC characterized by tumor-distended right upper pole calyx showing filling on delayed phase.

TABLE 1: DESCRIPTIVE CHARACTERISTICS OF STUDY PARTICIPANTS (N = 140)

Parameter	Category	Value
Age (years)	Mean ± SD	55.7 ± 13.1
Sex	Male	70% (98)
	Female	30% (42)
Presenting Complaints	Pain abdomen	34.3% (48)
	Hematuria	21.4% (30)
	Asymptomatic / Incidental finding	28.6% (40)
	Lower urinary tract symptoms	11.4% (16)
	Non-specific symptoms	4.3% (6)
Diagnosis	Renal cell carcinoma (RCC)	81.4% (114)
	Renal cyst	12.1% (17)
	Transitional cell carcinoma (TCC)	2.9% (4)
	Oncocytoma	1.4% (2)
	Tuberculosis	1.4% (2)
	Adult cystic nephroma	0.7% (1)
Subtype of RCC	Clear cell	74.6% (85)
	Papillary	17.5% (20)
	Chromophobe	7% (8)
	Fumarate hydratase deficient	0.9% (1)

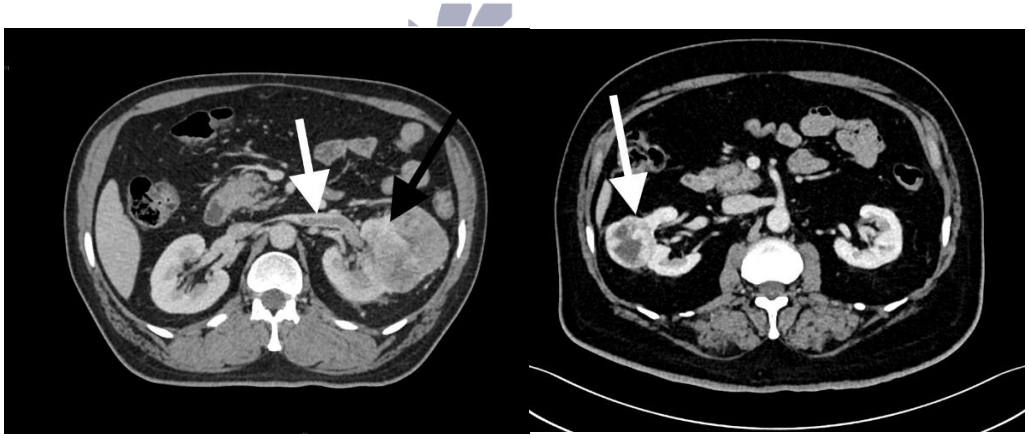

Figure IA: Shows a large lobulated heterogeneously enhancing, partially necrotic and exophytic left renal cortical based mass representing RCC as shown by black arrow. Tumor thrombus within the left renal vein is shown by white arrow.

Figure IB: An exophytic, fairly well-circumscribed, heterogeneously enhancing and partially necrotic mass arising from the upper pole and interpolar region of the right kidney, as shown by white arrow. Although similar to RCC, it came out to be

TABLE 2: CROSS-TABULATION OF MALIGNANT RENAL MASS ON MULTIDETECTOR CT VERSUS HISTOPATHOLOGY

Malignant Renal Mass on CT	Histopathology Absent	Histopathology Present	Total
Negative	18	2	20
Positive	4	116	120
Total	22	118	140

TABLE 3: DIAGNOSTIC ACCURACY OF MULTIDETECTOR CT IN DETECTION OF MALIGNANT RENAL MASSES

Statistic	Value	Confidence Interval
Sensitivity	98.31%	94.01% – 99.79%
Specificity	81.82%	59.72% – 94.81%
Positive Likelihood Ratio	5.41	2.23 – 13.12
Negative Likelihood Ratio	0.02	0.01 – 0.08
Disease Prevalence	84.29%	77.18% – 89.88%
Positive Predictive Value	96.67%	92.28% – 98.60%
Negative Predictive Value	90.00%	69.19% – 97.30%
Accuracy	95.71%	90.91% – 98.41%

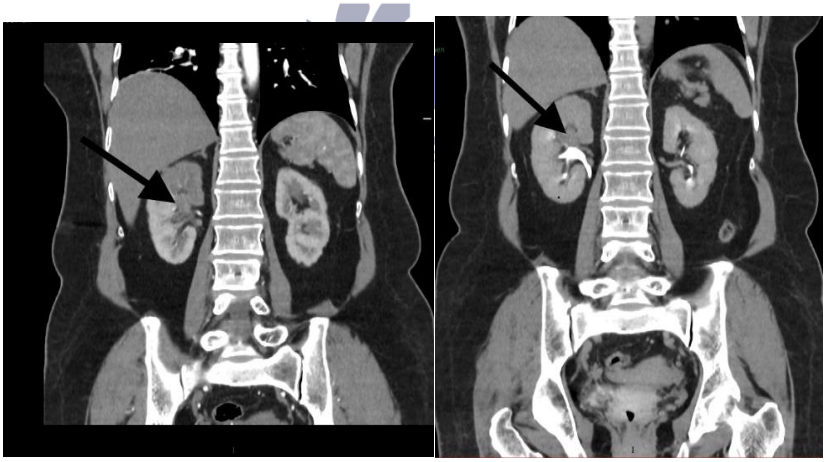

Figure IIA and IIB: Right kidney upper pole intra-calyceal lesion with effacement of the surrounding sinus fat as shown by black arrow. The upper pole of right kidney shows differential hypo-enhancement and no contrast excretion in the upper pole calyx seen as depicted by black arrow in the second image. This came out to be Transitional cell carcinoma (TCC) on biopsy.

DISCUSSION:

MDCT has emerged as a valuable imaging modality for evaluating renal masses, offering high spatial resolution, mutltiplanar imaging capabilities and functional information. It is superior to ultrasound in characterization of renal masses while still inferior to magnetic resonance imaging (MRI) especially for equivocal cases.

The most prevalent type of malignant renal tumor is RCC, formerly known as hypernephroma or Grawitz tumor. RCCs are primary malignant adenocarcinomas that originate from the renal tubular epithelium. At presentation, patients are usually between the ages of 50 and 70, with a moderate male predominance of 2:1, [9, 10] as can be seen in our study. The risk factor for RCC are: Obesity, hypertension, cigarette smoking, dialysis related cystic disease, treatment with cyclophosphamide and post renal transplant. [11] It has associations with hereditary renal cell cancer syndromes including: sickle cell disease, von Hippel-Lindau syndrome, tuberous sclerosis and Birt-Hogg-Dubé syndrome. Clinically, macroscopic hematuria is the most common presenting complaint followed by flank pain and palpable flank mass. Clear cell is the most common subtype of RCC followed by papillary and chromophobe subtypes which is seen in our study. One of the least common and most aggressive subtype of RCC is fumarate hydratase deficient [12] which was seen in only one out of 140 patients in our study. Ultrasound is the initial imaging modality to detect RCC however not as sensitive as CT especially for smaller masses. On CT RCC may appear as a soft tissue attenuation (20-70 HU) renal mass on non-contrast CT with larger lesions showing internal necrosis and 30% showing internal calcifications. [13] Following contrast administration, RCCs, particularly the clear cell type will show variable enhancement usually more than 20 HU as compared to non-contrast scan. Treatment of RCC is radical nephrectomy.

Compared to renal cell carcinoma, urothelial carcinoma (transitional cell carcinoma) of the renal pelvis is less prevalent. Generally speaking, urothelial carcinomas have soft tissue density (8–30 HU) and relatively slight enhancement (18–55 HU), which is normally far less enhancing than renal parenchyma or renal cell carcinomas (though the differentiation is not always possible). They vary in size from tiny filling defects to massive tumors that completely destroy the renal sinus fat. They are typically localized on the renal pelvis rather than the renal parenchyma as is the case with RCC. [14]

Another renal malignancy is renal lymphoma which may manifest as a component of multi-systemic lymphoma or primary renal lymphoma characterized by lymphoma that only affects the kidney and shows no signs of extra-renal lymphatic illness. Multiple bilateral hypo dense or infiltrative renal masses are common imaging findings. [15, 16] However we could not find any case of renal lymphoma in our study group. Moreover, Bosniak category III and IV cysts have 40–60% and 80% risk of malignancy, and surgical resection is recommended. [17]

Oncocytomas are benign renal tumors, but typically they are excised because their imaging appearance makes it difficult to differentiate them from renal cell cancer. Therefore, the false positive cases in our study were oncocytomas. They show up as well-defined lesions that vary in size but are frequently large when they first present. The presence of a prominent central stellate scar, which is typical of oncocytomas but only occurs in one-third of cases, is a potentially useful indicator. Furthermore, a central scar may be seen in renal cell carcinomas. [18]

According to reports, the incidence of cancer in Bosniak IIF cysts (cysts with 3mm enhancing walls or one or more 3mm septa or cysts with many septa which are less than or equal to 2mm) ranges from 0 to 38%.[19] These types of cysts were responsible for some of false negative cases in our study group. The true negatives in our study group were Bosnaik I (simple cysts), II (cysts with 1-3 ≤ 2mm septa or contain calcifications) and IIF cysts, adult cystic nephroma, renal tuberculosis. These patients underwent renal biopsies due to high clinical suspicions of malignancy. Angiomyolipomas (AMLs), which account for 2% to 6% of all surgically removed tumors, are benign neoplasms of mesenchymal origin made up of manure adipose tissue, smooth muscle, and aberrant blood vessels. On CT, they appear as fat attenuating lesions, however rarely RCC may also contain fat making the differentiation between the two difficult. We did not see any case of biopsy proven AML.

A meta-analysis conducted by Rebeca Miron et al showed that that contrast enhanced CT had 96% summary sensitivity and 92% summary specificity in differentiating malignant from benign renal lesions. [20] Another study evaluated the role of recently introduced CT based algorithm in diagnosing clear cell RCC among small renal masses. The used mass to renal cortex attenuation ratio along with heterogeneity score. A CT score of at least 4 was regarded as positive for clear cell type of RCC. This system showed sensitivity of 78% while specificity 59% in diagnosing clear cell type of RCC. [21] Another study conducted by Siddiqui MA, et al showed that the CT scan had 97.6% sensitivity, 100% specificity, 100% PPV, and 89.5% NPV in characterization or renal masses. [22]

There were few limitations of our study, i.e. lacking the diversity of cases; most of the cases were clear cell RCCs while other malignancies were less commonly encountered, single institute study and limited sample size. In future more such studies can be performed with more diverse cases and study population.

CONCLUSION:

MDCT plays crucial role in characterization of renal masses offering valuable information for diagnosis, staging and management. By understanding the imaging features and protocols, the radiologists and clinicians can work together to improve patient care in future.

CONFLICT OFF INTEREST:

Nil

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