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Diagnostic Accuracy of Contrast-Enhanced Computed Tomography in Small Renal Cell Carcinoma

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Author`s Contribution

[1,3]Substantial contributions to the conception or design of the work; or the acquisition, Drafting the work or revising it critically for important intellectual content [3]Supervision and Final approval. [4-6]Active participation in active methodology, analysis, or interpretation of data for the work

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ABSTRACT

Objective: To determine the diagnostic accuracy of contrast-enhanced computed tomography (CECT) in the diagnosis of small renal cell carcinoma (RCC), using histopathology as the reference gold standard.

Methodology: This cross-sectional study was conducted in the Department of Radiology, Civil Hospital, Karachi, from September 2020 to March 2021. All clinically suspected patients with small RCC, of either gender, were included. Contrast-enhanced CT of the abdomen was performed using intravenous contrast material. Imaging was acquired in the axial plane with multiplanar reformations in sagittal and coronal planes, with the patient in the supine position. A diagnosis of small RCC was made based on CT findings, and histopathology results were collected. Sensitivity, specificity, and diagnostic accuracy of contrast-enhanced CT of the abdomen were calculated using histopathology as the gold standard.

Results: Of the participants, 68.2% were male and 31.8% were female. The mean age was 56.54 ± 9.45 years. The mean duration of symptoms was 7.88 ± 2.31 weeks. The mean renal mass diameter was 2.54 ± 0.92 cm. Overall, 45.5% of patients were diagnosed with RCC on CT scan, while 52.7% were confirmed by histopathology. CECT demonstrated a sensitivity of 82.76%, specificity of 96.15%, positive predictive value (PPV) of 96%, negative predictive value (NPV) of 86.33%, and an overall diagnostic accuracy of 89.09% for diagnosing small RCC.

Conclusion: Contrast-enhanced CT offers high sensitivity and specificity for the accurate diagnosis of small renal masses.

Keywords: Diagnostic Accuracy, CECT, Small RCC.

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Introduction

Renal cell carcinoma (RCC) is the most prevalent malignant tumor of the kidney in adults and constitutes a growing global health burden. Kidney malignancies currently account for approximately 400,000 new cases and around 175,000 deaths per year worldwide.[1] Globally, renal carcinoma ranks as the sixth and ninth most common newly diagnosed malignancy in males and females, respectively, with clear cell RCC being the most common subtype in adults.[2]

In developing countries such as Pakistan, the burden of RCC poses additional challenges, highlighting the importance of reliable and accessible imaging modalities. Local clinicopathological data from Pakistan reveal that

RCC tends to present at a younger age compared to Western populations, with a notably larger mean tumor size (7.2 cm) and predominantly intermediate- to high-stage disease. This suggests that patients in this setting often present at more advanced stages.[3]

Although the incidence of RCC has been increasing largely driven by the widespread use of cross-sectional and advanced imaging techniques that enable earlier tumor detection—the overlapping imaging features of benign and malignant renal tumors continue to present a diagnostic challenge.[4]

In the developed nations, the most of the cases with RCC cases are identified incidentally during the imaging studies such as magnetic resonance imaging (MRI), CT, or sonography. Just around 10% of patients showed the classical symptom pattern, which includes hematuria, flank pain, and the palpable mass of abdomen.[5] This shift toward incidental diagnosis, along with the widespread use of cross-sectional imaging, has revealed in a marked rise in the detection of small masses of kidneys, typically defined as solid renal tumors measuring cm or less in greatest dimension, many of which characterize at early-stage of RCC without metastases.[6]

However, the contrast-enhanced CT has estimated as the keystone imaging modality for the assessment of masses of kidneys. With the solid masses of the kidney, the most imperative measure for differentiating malignant lesions is the presence of improvement; in CT imaging, a modification of fifteen Hounsfield units or more in the solid tumor portions shows enhancement and thus feasible tumor tissue.[7] Subsequently the CECT is considered as the standard imaging technique for local and distant staging, and the staging Tumor–Node–Metastasis strongly disturbs the prognosis and management among patients.[8] The triphasic CECT incorporating non-contrast, corticomedullary, and nephrographic phases permits characterization of vascularity of the tumor, local extension, size of tumor and venous involvements, forming the foundation of preoperative evaluation.

Regardless of its widespread use, the diagnostic accuracy of CECT remains an area of active investigation for small RCC. According to a systematic review of imaging modalities determined that for CT, median sensitivity 88% and specificity 75%, with contrast-enhanced CT and MRI remaining the diagnostic support for RCC with approximately equally high diagnostic and staging accuracy.[9] In the context of local staging overall accuracy for correct T staging was 80%, the CECT is a reliable modality for local T staging of RCC, demonstrating high sensitivity and specificity in assessing tumor size, as well as in identifying extension into adjacent structures and the venous involvement.[8] On the other hand, a discrepancy rate of approximately 20% between CT imaging and pathology has been reported, with smaller renal masses under 2 cm being associated with a significantly higher likelihood of diagnostic discrepancy between imaging and final histopathology.[10] The limitations of diagnosis carry meaningful clinical significances, as misclassification of the benign lesions as the malignant may subject cases to unnecessary surgeries and its related morbidity. Ultimately purpose of evolving imaging approaches is to avoid unnecessary surgery for the benign tumor, minimizing the morbidity of patients and damage of renal function, and ideally renal cancer diagnosis using imaging only, decrease the requirement for renal biopsies.[11] Based on given imposing, the present study was planned to assess the diagnostic accuracy of CECT in small RCC, with histopathological results as the reference standard.

Methodology

This descriptive cross-sectional study was conducted at the Department of Radiology, Dow University of Health Sciences, Civil Hospital Karachi, from September 2020 to August 2021. Patients aged 31 to 70 years, of both genders, with clinically suspected small renal cell carcinoma (RCC) and referred to the Radiology Department of Civil Hospital Karachi for a CT scan of the abdomen were included in this study. Patients with simple renal cysts on ultrasound, appearing as well-defined anechoic lesions with posterior acoustic shadowing, biopsy-proven cases of RCC, and those with a history of previous surgery involving the affected kidney were excluded.

Suspected small renal cell carcinoma was defined as a solid renal parenchymal mass of approximately 4 cm or less on abdominal ultrasound, present for at least four weeks, and associated with one or more of the following: incidentally detected renal mass, mild lumbar pain occurring at least three days per week without limiting daily activities, or hematuria (gross or microscopic) with more than ten red blood cells per high-power field on urine detailed report (DR).

Informed consent was obtained from each patient after explaining the purpose and procedure of the study. A complete medical history and demographic information

were recorded. Contrast-enhanced computed tomography (CECT) of the abdomen was performed in the Radiology Department using a Toshiba Activion multislice CT scanner with the administration of intravenous contrast material.

CT imaging was performed in the axial plane with multiplanar reformations in the sagittal and coronal planes, with the patient in the supine position. Images were analyzed by a senior radiologist with at least five years of post-fellowship experience. Small RCC on CT scan was defined as a solid renal parenchymal mass measuring <4 cm, diagnosed when more than two of the following features were present: a homogeneous or heterogeneous soft tissue density mass with an attenuation value of ≥20 Hounsfield units, appearing isodense to hyperdense on pre-contrast images; contrast enhancement of ≥20 Hounsfield units on post-contrast images; or abdominal lymphadenopathy with loss of fatty hilum and architectural distortion.

Subsequently, patients were followed up for histopathological assessment using surgical or biopsy specimens, with histopathology serving as the reference standard against which the diagnostic accuracy of CECT was evaluated in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy. A database was developed using SPSS for Windows version 21.0.

Results

The study cohort had a mean age of 55.83 ± 6.0 years, with symptoms present for a mean of 7.88 ± 2.31 weeks and a renal mass diameter of 2.54 ± 0.92 cm on CT. Males were predominant 75 (68.2%) compared with females 35 (31.8%). A total of 84 patients 42(38.2%) had a history of smoking and 14 (12.7%) patients had a history of alcohol intake. Table I

Table I: Baseline and clinical variable analysis of the patients. (n=110)

Variables	Subcategory	Statistics
Age		55.83 ± 6.0 years
Symptom Duration weeks		7.88 ± 2.31
Renal Mass Diameter		2.54 ± 0.92 cm
Gender	Male	75 (68.2%)
	Female	35 (31.8%)
Smoking History	Yes	42(38.2%)
	No	68 (60.8%)
Alcohol Intake History	Yes	14 (12.7%)
	No	96 (87.3%)

Out of all, CECT identified small RCC among 50 (45.5%) patients, while histopathological examination, serving as the reference standard, detected the considerably some higher number of positive cases around 58 (52.7%), indicating that CECT alone may underdiagnosed RCC when compared to histopathology. Table II

Table II: RCC diagnosis by CECT and histopathology. (n=110)

Diagnostic Method	RCC Positive	RCC Negative	Total
CECT	50 (45.5%)	60(54.5%)	110
Histopathology (Table 11)	58 (52.7%)	52 (47.3%)	110

The CECT showed a sensitivity of 82.76%, specificity of 96.15%, PPV 96%, NPV 86.33%, and diagnostic accuracy around 89.09%, by taking histopathology as the gold standard, in diagnosing small RCC, as shown in table III.

Table III: Diagnostic accuracy of CECT in the diagnosis of small RCC taken histopathology as gold standard. (n= 110)

CT SCAN	HISTOPATHOLOGY			P-value
	Positive	Negative	Total	0.001
Positive	48(43.6%)	2(1.8)	50	
Negative	10(9.1)	50(45.5)	60	
TOTAL	52	58	110	
Sensitivity	Specificity	PPV	NPV	Accuracy
82.76%	96.15%	96.00%	83.33%	89.09%

Particularly the CECT showed consistently high diagnostic accuracy for small RCC without significant difference in the performance across the subgroups. However, the sensitivity, specificity, PPV, NPV, and overall accuracy remained almost comparable between genders (with females showing slightly higher specificity), younger and older age groups (with <55 years aged patients slightly better sensitivity and overall accuracy), and small versus large renal masses (some better performance in larger renal masses), confirming

Table IV: Post stratification diagnostic accuracy of CECT taking histopathology as gold standard, based on age, gender and renal mass diameter. (n= 110)

Subgroup	n	Sensitivity	Specificity	PPV	NPV	Accuracy
Male	75	85.37%	94.12%	94.59%	84.21%	92.33%
Female	35	82.47%	97.32%	95.34%	81.82%	90.57%
Age <55 years	57	86.36%	96.77%	95.00%	90.91%	92.45%
Age >55 years	53	83.56%	95.24%	96.67%	85.07%	89.96%
Renal mass diameter <3 cm	16	81.63%	95.56%	95.24%	82.69%	88.30%
Renal mass diameter >3 cm	94	88.89%	98.00%	97.44%	87.50%	94.75%

that CT is a reliable diagnostic tool for RCC regardless of gender, age, or tumor size. Table IV

Discussion

The accurate and timely diagnosis of small RCC remains a significant clinical challenge, as early identification is directly associated with improved surgical outcomes, higher rates of nephron-sparing surgery, and reduced disease-related mortality. Contrast-enhanced computed tomography (CECT) has long been considered the primary imaging modality for the radiological evaluation of renal masses; however, its diagnostic performance in characterizing small masses of <4 cm remains a subject of substantial debate and ongoing investigation in contemporary urological and radiological literature. This study was conducted on 249 patients to determine the diagnostic accuracy of CECT in the diagnosis of RCC, taking histopathological evaluation as the reference gold standard.

In this study, CECT demonstrated a sensitivity of 82.76%, specificity of 96.15%, positive predictive value (PPV) of 96%, negative predictive value (NPV) of 86.33%, and an overall diagnostic accuracy of 89.09% for the diagnosis of small RCC, indicating that CECT is a reliable and accurate imaging modality for RCC detection. Consistent with these findings, Munir A et al.[12] reported a sensitivity of 89.47%, specificity of 89.47%, PPV of 94.44%, NPV of 83.33%, and an overall diagnostic accuracy of 90% for CECT in detecting RCC. Similarly, Akram F et al.[13] conducted a study with a comparable objective and reported a diagnostic accuracy of 73.45%, sensitivity of 94.37%, and specificity of 38.10%.

Our findings were also supported by a study from Bangladesh, where Nahar S et al.[14] reported a diagnostic accuracy of 98% for CECT in the diagnosis of RCC, with a sensitivity of 97.73%, specificity of 100%, PPV of 100%, and NPV of 85.7%. On the other hand, Millet et al15 conducted the study for CT diagnostic accuracy where histopathological examination of biopsy specimens use as the reference standard, and revealed a progressive enhancement as a diagnostic indicator of benignity yielded with sensitivity of 60%, specificity 73%, 43% PPV, and 84% NPV. In the study by Kim JH et al16 also observed that the Contrast-enhanced CT is a valuable diagnostic tool with sensitivity of 79.7% and 44.4% specificity in predicting RCC. A systemic review by Shen J et al17 showed comparable findings where they observed that the CECT is documented as a highly valuable imaging tool for the detection of RCC, as it enhances lesion contrast against surrounding tissues through the use of contrast agents, thus empowering more precise characterization of lesions and facilitating earlier and more accurate diagnosis preoperatively. However, the Mlambo NE et al18 reported that the CT showed PPV around 81% for RCC, while cystic tumors and those measuring 4 cm or less were more often found to be benign. Nevertheless, the CT showed good specificity in detecting extra-renal extension, vascular invasion, and involvement of the lymph node, while its sensitivity for these features remained remarkably limited. In the study by Yanagi M et al19 reported that the detection of calcified vessels on CECT serves as a useful differentiating feature in distinguishing the small fat-poor angiomyolipomas from RCC.

Demographically in this study mean age of the patients was 56.54 ± 9.45 years and a clear male predominance 75 (68.2%) compared to females 35 (31.8%), which is indicating that the RCC occurring more frequently among males and typically manifesting at an advanced age, reflecting the tendency of disease to present in the fifth to seventh decades of life, and these findings were supported by the Dahlmann S et al[20] and Mohamed AH et al[21]. Overall studies found the CECT as reliable diagnostic tool for detection of small RCC. However present study still carries several limitations like relatively small sample size, which may affect the generalizability of the findings, and the study was conducted exclusively in an urban setting, the findings may not be fully representative of or generalizable to broader and more diverse population groups, as well as rural communities where patient demographics, presentation of disease, and access to the diagnostic facilities may differ substantially. Consequently, future large-scale multicenter studies encompassing both urban and rural populations are recommended to explore the more comprehensive and widely applicable observations.

Conclusion

The CECT scan concluded to be a accurate and reliable imaging modality for the RCC diagnosis, with high sensitivity, specificity and overall diagnostic accuracy. It shows strong ability to confirm the presence of RCC with few false positives. Subsequently it performs well in ruling out disease in most of the patients, while a negative CT result does not completely exclude RCC, and clinical judgment should always be considered alongside findings of imaging. Overall with its good

diagnostic performance, the CT remains an investigative tool but cannot replace tissue diagnosis. Hence, histopathological confirmation remains still very essential for the definitive diagnosis of small RCC.

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