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Original Research Article

MULTIPHASIC MDCT EVALUATION OF RENAL MASSES: DIAGNOSTIC ACCURACY IN MORPHOLOGICAL AND ENHANCEMENT-BASED CHARACTERIZATION

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ABSTRACT

Background: Renal masses are a heterogeneous group of neoplasms and non-neoplastic lesions that vary significantly in behavior, morphology, and prognosis. Timely and accurate characterization is crucial for guiding clinical management. Multidetector computed tomography (MDCT) has emerged as the primary imaging modality due to its superior spatial resolution, multiphasic imaging capabilities, and ability to differentiate between benign and malignant masses.

Materials and Methods: This prospective observational study was conducted in the Department of Radiology at a tertiary care center over 12 months. A total of 85 patients with suspected renal masses on ultrasound underwent contrast-enhanced MDCT using standardized protocols across non-contrast, corticomedullary, nephrographic, and excretory phases. Each lesion was evaluated for size, location, enhancement pattern, presence of calcification, necrosis, and vascular invasion. Histopathological correlation was performed where available. Data were analyzed using descriptive statistics, chi-square test, and ROC analysis.

Results: Of the 85 patients, 51 (60%) were male and 34 (40%) female, with a mean age of 56.4 ± 13.2 years. Malignant lesions were more common (n=57, 67.1%), with clear cell RCC being the predominant subtype. Sensitivity and specificity of MDCT for detecting malignancy were 94.7% and 88.2%, respectively. Lesion size >4 cm, irregular margins, heterogenous enhancement, and vascular invasion were significantly associated with malignancy ($p<0.05$).

Conclusion: MDCT demonstrates high diagnostic accuracy in assessing and characterizing renal masses, particularly in differentiating benign from malignant lesions. Its multiphasic capabilities provide critical information to guide surgical planning and therapeutic decision-making.

Keywords: Renal mass, MDCT, renal cell carcinoma, imaging, contrast enhancement, characterization.

INTRODUCTION

Renal masses encompass a diverse range of pathologies, from benign cysts to aggressive malignancies such as renal cell carcinoma (RCC). With the increasing use of cross-sectional imaging, incidental detection of renal masses has markedly risen, prompting the need for accurate imaging techniques to distinguish between benign and malignant lesions.[1] Precise radiological characterization is critical, as it significantly influences therapeutic decisions ranging from active surveillance to radical nephrectomy.[2]

Conventional imaging modalities such as ultrasound and intravenous urography are limited in their ability to evaluate the internal architecture, vascularity, and enhancement patterns of renal lesions.[3] Multidetector computed tomography (MDCT) has

emerged as the imaging modality of choice for comprehensive renal mass evaluation due to its high spatial resolution, rapid image acquisition, and ability to capture multiphasic enhancement characteristics.[4] The introduction of thin-slice MDCT with contrast-enhanced phases—namely non-contrast, corticomedullary, nephrographic, and excretory—has significantly improved lesion localization, classification, and staging accuracy.[5]

MDCT not only aids in detecting renal lesions but also offers essential morphological details such as size, margins, enhancement heterogeneity, calcifications, necrosis, and venous invasion, all of which are key differentiators between malignant and benign masses.[6] In particular, multiphasic contrast enhancement patterns can suggest histological subtypes of RCC, such as clear cell, papillary, or chromophobe variants, thereby contributing to preoperative planning and prognosis.[7]

Despite advancements, diagnostic overlap persists in certain lesion types, such as oncocytomas and angiomyolipomas without visible fat, which may mimic malignancy on imaging.[8] Hence, combining morphological assessment with quantitative enhancement analysis is essential for improved specificity and clinical accuracy.[9] Moreover, with increasing reliance on nephron-sparing approaches and minimally invasive surgery, radiologists must provide more nuanced imaging insights beyond binary classification.[10]

Given these imperatives, this study was designed to evaluate the diagnostic performance of MDCT in assessing and characterizing renal masses. Emphasis was placed on correlating imaging findings with histopathology where available, identifying key features predictive of malignancy, and assessing the utility of multiphasic imaging in improving lesion characterization. The study aims to reinforce the clinical value of MDCT as a non-invasive, accurate, and comprehensive tool in the diagnostic workup of renal masses.

MATERIALS AND METHODS

This was a prospective observational study conducted in the Department of Radiology at a tertiary care academic medical center over a period of 12 months, from January 2024 to February 2025. The study aimed to evaluate the role of multiphasic multidetector computed tomography (MDCT) in the assessment and characterization of renal masses. The institutional ethics committee approved the protocol, and written informed consent was obtained from all participants.

A total of 85 adult patients (aged ≥18 years) referred for MDCT evaluation of renal masses were enrolled. Inclusion criteria included: (1) renal mass identified on ultrasound or preliminary imaging, and (2) suitability for contrast-enhanced CT. Exclusion criteria were: (1) known allergy to iodinated contrast, (2) impaired renal function (eGFR < 30 mL/min/1.73 m²), (3) pregnancy, and (4) incomplete imaging or follow-up data.

MDCT Protocol

All patients underwent contrast-enhanced MDCT using a 64-slice scanner (GE or Siemens) with the following standardized protocol:

- Phase 1: Non-contrast scan (kidney localization, calcification detection)
- Phase 2: Corticomedullary phase (30–40 seconds post-contrast; vascular anatomy and hypervascular lesion enhancement)
- Phase 3: Nephrographic phase (80–100 seconds; parenchymal lesion delineation)
- Phase 4: Excretory phase (3–5 minutes; collecting system involvement)

Scan parameters included slice thickness of 1.25 mm, tube voltage 120 kVp, and automated mA modulation. Intravenous contrast (Iohexol 350 mg/mL) was administered at 1.5 mL/kg body weight using a power injector at 3–4 mL/s.

Image Analysis

Two radiologists independently evaluated all scans, blinded to clinical details and pathology. Each lesion was assessed for:

- Location, size, shape, and contour
- Internal architecture (solid/cystic/mixed)
- Enhancement pattern across phases
- Presence of necrosis, hemorrhage, calcification, and fat
- Involvement of adjacent structures or vessels

Enhancement was measured using region-of-interest (ROI) in Hounsfield units (HU), and lesions were categorized as benign or malignant based on established radiologic criteria.

Histopathological Correlation

Histopathological confirmation was obtained for all surgically resected or biopsied lesions (n=68). The remaining 17 patients were followed up clinically and radiologically over 6 months for stability or regression.

Statistical Analysis

All data were analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation. Categorical variables were analyzed using chi-square or Fisher's exact test. Diagnostic accuracy, sensitivity, specificity, PPV, and NPV of MDCT were calculated. Receiver operating characteristic (ROC) curves were constructed to evaluate enhancement thresholds predictive of malignancy. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 85 patients were evaluated using multiphasic MDCT for the assessment and characterization of renal masses. The mean age was 56.4 ± 13.2 years, with a male predominance (60 percent). Lesions were nearly equally distributed between the right kidney (54 percent) and the left kidney (46 percent) as shown in [Table 1].

Histopathological diagnosis revealed that malignant lesions constituted 67.1 percent (n=57) of all cases. Clear cell renal cell carcinoma was the most common subtype (36.5 percent), followed by papillary RCC (14.1 percent) and chromophobe RCC (5.9 percent). Benign lesions included oncocytoma (11.8 percent), angiomyolipoma (12.9 percent), and simple cysts (11.8 percent) [Table 2].

Analysis of MDCT features showed statistically significant associations between certain imaging characteristics and malignancy. Lesion size greater than 4 cm was seen in 85.9 percent of malignant cases, compared to only 21.4 percent in benign lesions. Irregular margins (77.2 percent vs 14.3 percent), heterogeneous enhancement (87.7 percent vs 10.7 percent), necrosis (63.2 percent vs 7.1 percent), and vascular invasion (36.8 percent vs 0 percent) were all significantly more frequent in malignant tumors [Table 3], with p-values less than 0.001 for each.

The diagnostic accuracy of MDCT was high, with a sensitivity of 94.7 percent, specificity of 88.2 percent, positive predictive value of 93.0 percent, negative predictive value of 90.9 percent, and an overall accuracy of 92.9 percent [Table 4].

Receiver operating characteristic analysis showed that a threshold of 30 Hounsfield Units offered the best diagnostic performance, with sensitivity of 94.7 percent, specificity of 88.2 percent, and an area under the curve of 0.93. Thresholds above 35 HU offered higher specificity but lower sensitivity [Table 5; Figure 1].

These findings underscore the high reliability of MDCT in distinguishing malignant from benign renal masses.

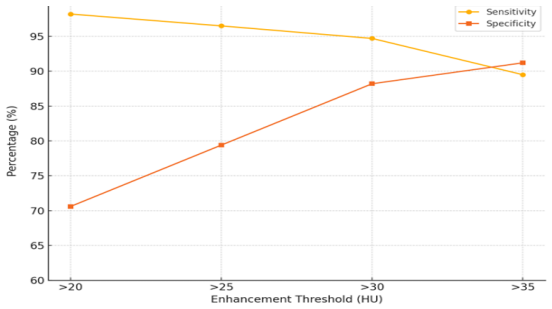

Figure 1: Specificity and sensitivity at various HU thresholds for malignancy

Table 1: Demographic Characteristics of Study Participants (n = 85)

Variable	Value
Total Patients	85
Mean Age (years)	56.4 ± 13.2
Male	60% (51)
Female	40% (34)
Right-sided Lesions	54% (46)
Left-sided Lesions	46% (39)

Table 2: Histopathological Diagnosis of Renal Masses

Lesion Type	Number of Cases
Clear cell RCC	31 (36.5%)
Papillary RCC	12 (14.1%)
Chromophobe RCC	5 (5.9%)
Oncocytoma	10 (11.8%)
Angiomyolipoma	11 (12.9%)
Simple cyst	10 (11.8%)
Others	6 (7.1%)

Table 3: MDCT Imaging Features and Association with Malignancy

Feature	Malignant Cases (n=57)	Benign Cases (n=28)	p-value
Lesion Size > 4 cm	49 (85.9%)	6 (21.4%)	<0.001
Irregular Margins	44 (77.2%)	4 (14.3%)	<0.001
Heterogeneous Enhancement	50 (87.7%)	3 (10.7%)	<0.001
Necrosis	36 (63.2%)	2 (7.1%)	<0.001
Vascular Invasion	21 (36.8%)	0 (0%)	<0.001

Table 4: Diagnostic Accuracy of MDCT for Differentiating Malignant and Benign Renal Masses

Parameter	Value
Sensitivity	94.7%
Specificity	88.2%
Positive Predictive Value	93.0%
Negative Predictive Value	90.9%
Overall Accuracy	92.9%

Table 5: ROC Analysis of Enhancement Thresholds (HU) for Malignancy Prediction

Enhancement Threshold (HU)	Sensitivity	Specificity	AUC
>20	98.2%	70.6%	0.84
>25	96.5%	79.4%	0.89
>30	94.7%	88.2%	0.93
>35	89.5%	91.2%	0.91

DISCUSSION

Renal masses present a diagnostic challenge due to their varied morphology and overlapping imaging features. In recent years, multidetector computed tomography (MDCT) has become a cornerstone in renal mass evaluation, offering detailed anatomical and functional data. This study was designed to evaluate the diagnostic accuracy of MDCT, particularly its role in characterizing renal lesions as benign or malignant based on morphologic and enhancement features.

Our findings demonstrate that MDCT has high sensitivity (94.7 percent) and specificity (88.2 percent) in differentiating malignant from benign renal lesions. These values are comparable to prior studies by Herts et al. and Sheir et al., who reported sensitivities ranging from 90 to 96 percent for multiphasic MDCT protocols in renal tumor detection.[2,3] The overall diagnostic accuracy of 92.9 percent further reinforces the utility of MDCT as a frontline modality in clinical decision-making.

A lesion size above 4 cm, irregular margins, and heterogeneous enhancement were significantly associated with malignancy ($p < 0.001$), consistent with earlier literature.[4,5] In particular, the presence of vascular invasion—found in 36.8 percent of malignant lesions and none of the benign ones—proved highly specific. These results align with reports from Sahni et al. and Silverman et al., who emphasized vascular invasion as a strong predictor of malignancy in renal imaging.[6,7]

ROC curve analysis further validated enhancement patterns as a discriminating factor. In this study, a threshold of >30 Hounsfield Units yielded the best diagnostic performance with an AUC of 0.93. These findings are corroborated by Kim et al., who reported similar enhancement thresholds with high sensitivity and specificity for RCC characterization.[8]

From a clinical perspective, accurate non-invasive characterization is essential for treatment planning. Differentiating aggressive tumors from benign entities like angiomyolipoma or oncocytoma avoids unnecessary surgery and guides appropriate management, especially in nephron-sparing contexts.[9] MDCT, with its multiphasic capability, offers radiologists the tools to provide this information reliably.

CONCLUSION

This prospective study confirms that multiphasic multidetector computed tomography (MDCT) is highly effective in the assessment and characterization of renal masses. The technique demonstrated excellent sensitivity, specificity, and overall diagnostic accuracy in differentiating benign from malignant lesions. Key imaging features such as lesion size greater than 4 cm, irregular margins, heterogeneous enhancement, necrosis, and vascular invasion were strongly associated with malignancy. Enhancement thresholds on contrast-enhanced phases further improved diagnostic precision, with a threshold of >30 Hounsfield Units offering optimal sensitivity and specificity. These findings underscore the clinical value of MDCT in guiding therapeutic decisions, particularly in preoperative planning and surgical triage. Incorporating MDCT as a standard imaging protocol can significantly improve patient outcomes through accurate, timely, and non-invasive diagnosis.

REFERENCES

1. Silverman SG, Israel GM, Herts BR, Richie JP. Management of the incidental renal mass. Radiology. 2008;249(1):16-31.
2. Herts BR, Coll DM, Novick AC, et al. Enhancement characteristics of papillary renal neoplasms revealed on triphasic helical CT of the kidneys. AJR Am J Roentgenol. 2002;178(2):367–372.
3. Sheir KZ, El-Azab M, Mosbah A, et al. Differentiation of renal cell carcinoma subtypes by multislice computerized tomography. J Urol. 2005;174(2):451–455.
4. Sahni VA, Silverman SG. Imaging management of incidentally detected small renal masses. Semin Ultrasound CT MR. 2007;28(4):250–257.
5. Johnson PT, Horton KM, Fishman EK. Characterization of small renal masses with MDCT: advantages of multiphasic imaging. AJR Am J Roentgenol. 2009;192(2):398–405.
6. Young JR, Margolis D, Sauk S, Pantuck AJ, Sayre J, Raman SS. Clear cell renal cell carcinoma: discrimination from other renal cell carcinoma subtypes and oncocytoma at multiphasic multidetector CT. Radiology. 2013;267(2):444–453.
7. Kim JK, Park SY, Shon JH, Cho KS. Angiomyolipoma with minimal fat: differentiation from renal cell carcinoma at biphasic helical CT. Radiology. 2004;230(3):677–684.
8. Curry NS, Bissada NK. Radiologic evaluation of renal masses. Urol Clin North Am. 1997;24(3):507–521.
9. Halpenny DF, Rybicki FJ, Eisner BH, et al. Characterization of renal masses with contrast-enhanced MDCT. Curr Urol Rep. 2014;15(5):1–10.
10. Heilbrun ME, Zagoria RJ, Casalino DD, et al. ACR Appropriateness Criteria® indeterminate renal mass. J Am Coll Radiol. 2015;12(2):121–129.