

Original Article

Diagnostic Accuracy of Contrast-Enhanced Computed Tomography in the Characterization of Cystic Renal Cell Carcinoma

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Abstract

Objectives: To determine the diagnostic accuracy of contrast-enhanced computed tomography in characterizing cystic renal cell carcinoma, using histopathology as the gold standard.

Methodology: This prospective diagnostic accuracy study was conducted in the Radiology Department of Allied Hospital II, Faisalabad. 33 patients with suspected cystic renal lesions aged ≥ 18 years undergoing abdominal CT for renal evaluation were included. CT findings were categorized using the Bosniak classification system and compared with histopathological findings. We calculated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy. We used IBM SPSS version 26.0 to analyze the data.

Results: Histopathological findings confirmed cRCC in 20 (60.6%) patients, whereas 13 (39.4%) lesions were benign. Comparison of CECT findings with histopathology showed 19 true positives, 11 true negatives, 2 false positives, and 1 false negative. Consequently, 95.0% sensitivity, 84.6% specificity, 90.5% (PPV), 91.7% (NPV), and 90.9% total diagnostic accuracy was obtained. A statistically significant correspondence ($p < 0.001$) was seen between the histopathological findings and Bosniak classification, indicating that higher Bosniak categories were strongly associated with malignant cystic renal lesions.

Conclusion: This study concluded that CECT showed high diagnostic performance for the characterization of cRCC when compared with histopathology as the gold standard. CECT can be an effective imaging modality to guide appropriate clinical management and surgical decision-making.

Introduction

Cystic renal lesions are often encountered incidentally during abdominal imaging. A renal cyst is termed cystic renal cell carcinoma when it shows malignant features. Simple renal cysts are detected on ultrasonography during abdominal scans; sometimes these cysts are misdiagnosed as benign solid masses, which are usually not aggressive, but further investigation with contrast-enhanced ultrasound shows some structural irregularity. For standard evaluation and diagnosis, contrast-enhanced computed tomography is preferred. Cystic renal cell carcinoma (cRCC) is a unique type of renal malignancy. Because of its rare nature, cystic renal cell carcinoma has unclear imaging manifestations [1]. Cystic renal cell carcinoma is a diagnostically challenging malignancy; usually, it is confounded or misinterpreted as a solid, asymptomatic benign cyst because its own characteristics are insufficiently understood. Its rarity makes it an easily misdiagnosed renal neoplasm [2]. Misdiagnosis occurs because imaging features are poorly investigated; most previous studies and available literature consist of case reports, and better diagnosis of cystic renal carcinoma is missed; therefore, larger prospective studies are required to confirm the imaging features. [3].Cystic renal cell carcinoma shows slow progression, slow growth rate, and a lower chance of metastasis. It typically behaves as a low-grade kidney tumor. Because of this behavior, it is considered indolent [4].Renal cysts are classified based on the Bosniak classification v2019. Morton A. Bosniak introduced the classification; Bosniak I and II lesions are considered benign, whereas Bosniak IIF lesions require follow-up, and Bosniak III and IV lesions have progressively higher malignancy risks. Computed tomography is considered the cornerstone imaging tool for characterizing cystic renal cell carcinoma. It is a convenient, rapid detection modality. It provides precise anatomical detail and helps assess malignancy risk. Widespread adoption of cross-sectional imaging has also increased the incidental findings of cysts or masses [5]. Imaging studies show greater difficulty in differentiating cystic renal cell carcinoma from cysts because of superimposed structures. Therefore, a conservative surgical approach is a therapeutic option for managing cystic renal cell malignancy [6]. Given the improving diagnostic confidence and accuracy of contrast-enhanced computed tomography, this study is significant. Additionally, this study addresses gaps in previous research. Previous studies were mostly case reports, but the current study is based on prospective data from patients undergoing cross-sectional imaging. The study aims to document a series of novel cystic renal cell carcinomas.

Material and Methods

This Prospective diagnostic accuracy study was conducted in the radiology department of a tertiary care hospital, Allied Hospital II, Faisalabad.from March to May 2026. using a 16-slice Toshiba CT scanner for a period of 4

months. The study included Inpatients, outpatients, and referred patients who underwent abdominal (KUB) CT scans. We selected patients using consecutive non-probability sampling. We obtained written informed consent from each patient. We included patients aged ≥18 who underwent contrast-enhanced CT examination of the kidneys, ureters, and bladder (KUB). Pregnant patients, patients with known metastatic RCC, patients with prior nephrectomy for RCC, patients with contraindications to contrast (e.g., renal failure), and patients with a history of Renal Surgery or previous renal intervention were excluded.We recorded demographic and clinical data, including age, gender, history, and presenting symptoms, using a structured data collection form. The radiologist reviewed and interpreted well-demonstrated contrast-enhanced computed tomography scans to document lesion size, nature, wall thickness, calcifications, septations, and Bosniak level in the radiology report. An experienced pathologist performed histopathology, and findings were obtained. All data were entered into IBM SPSS version 26.0 for statistical analysis.

Results

The current study included 33 patients. Table 4.1 shows that the 46–60 years age group comprised the largest percentage of patients (33.3%), followed by the 31–45 years age group (30.3%). Patients over 60 and those aged 18- 30 made up 18.2% of the study population.

Table 41: Age distribution among study population

Age Group (Years)	Frequency (n=33)	Percentage (%)
18–30	6	18.2
31–45	10	30.3
46–60	11	33.3
>60	6	18.2

Figure.4.1 shows graphical representation of Age distribution

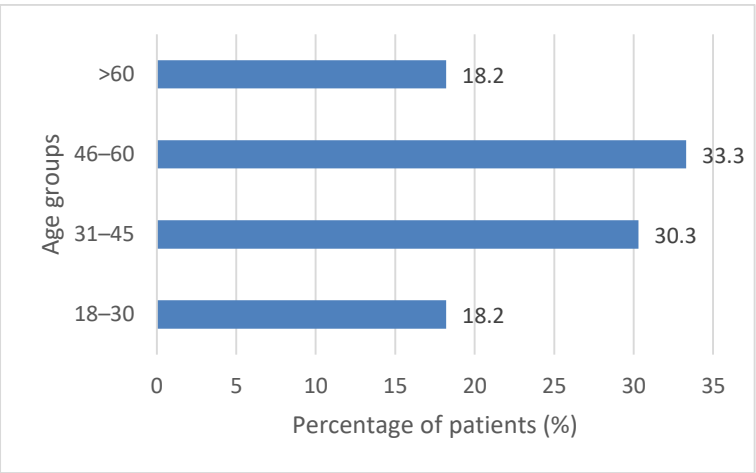


Figure 4.2: Gender Distribution

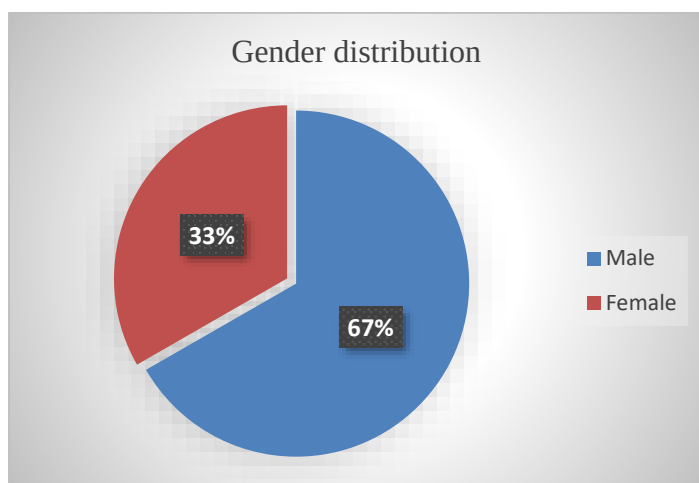


Figure 4.2 shows a graphical representation of Gender distribution. Among the study participants, males were predominant, accounting for 66.7% of the total sample, whereas females represented 33.3%.

Table 4.2: Clinical Presentation

Clinical Variable	Frequency	Percentage
Flank Pain	20	60.6
Hematuria	11	33.3
Incidental Finding	2	6.1

Flank pain was the most common presenting complaint (60.6%), followed by hematuria (33.3%). Two patients (6.1%) were diagnosed incidentally during abdominal CT examination.

Figure 4.3: Graphical representation of clinical symptoms

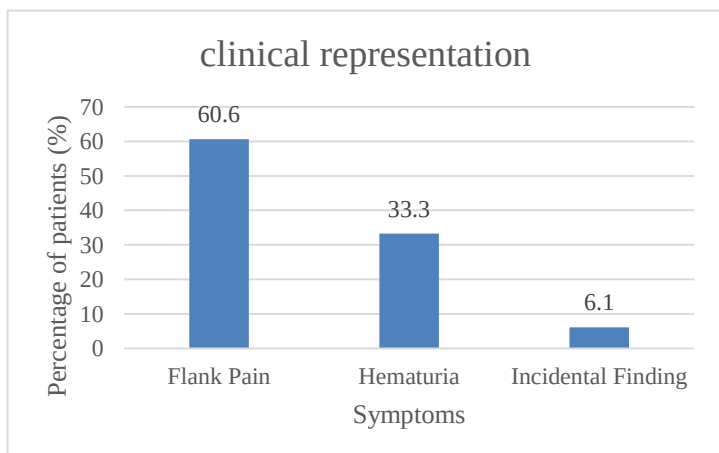


Figure 4.4: Past Renal Disease

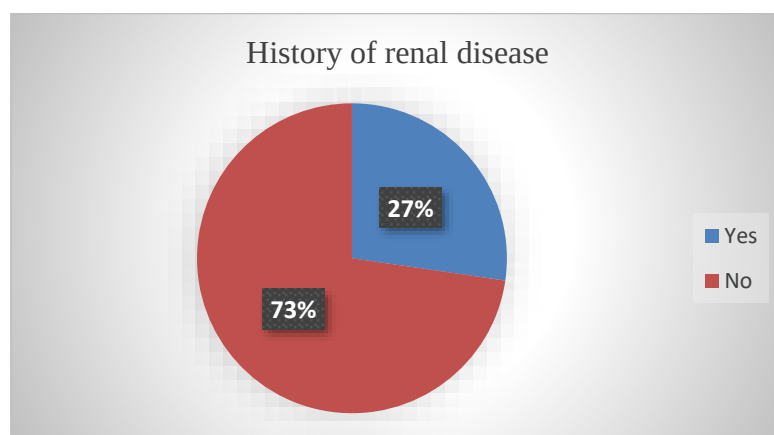


Figure 4.4 shows that most patients (72.7%) had no previous history of renal disease.

Figure 4.5: Family History of RCC

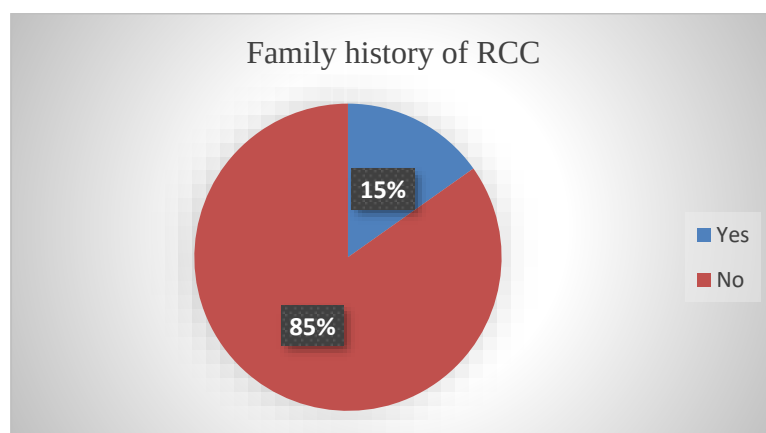


Fig. 4.5 shows the family history of renal cell carcinoma in the data sample.

Figure 4.6: Lesion Size

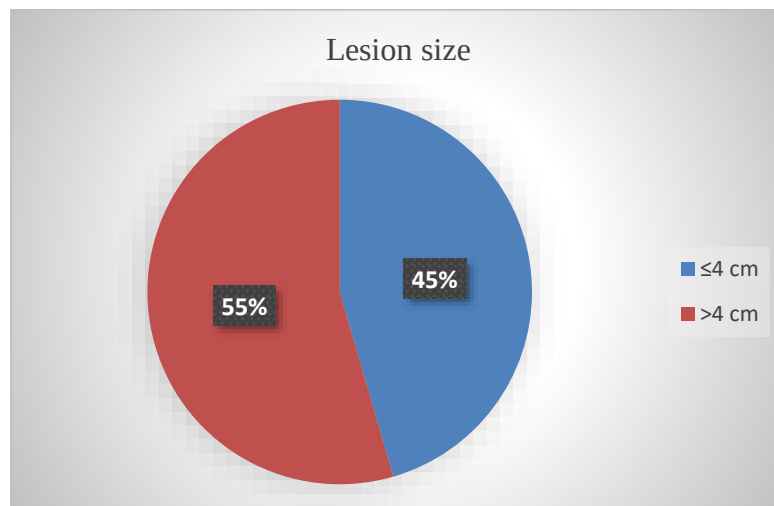
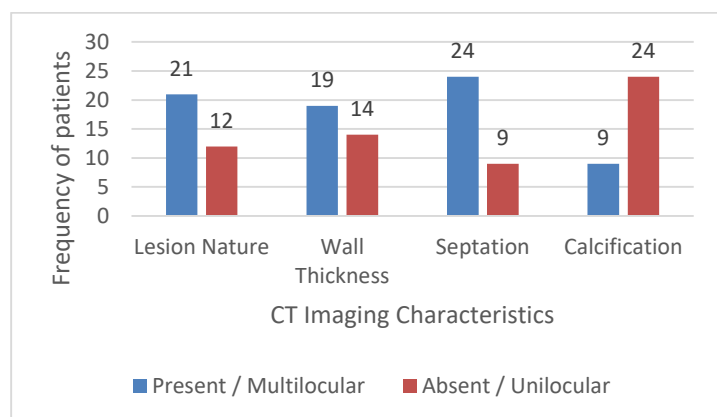


Fig. 4.6 shows the lesion size measurement in the data sample.

Table. 4.3: Distribution of CT Imaging Characteristics of Cystic Renal Lesions (n = 33)

Variable	Category	Frequency (n)	Percentage (%)
Lesion Nature	Unilocular	12	36.4
	Multilocular	21	63.6
Wall Thickness	Present	19	57.6
	Absent	14	42.4
Septations	Present	24	72.7
	Absent	9	27.3
Calcification	Present	9	27.3
	Absent	24	72.7

Table 4.3 presents the CT imaging characteristics of cystic renal lesions among the study participants. Multilocular lesions were more common than unilocular lesions, accounting for 63.6% and 36.4% of cases, respectively. Wall thickening was present in 57.6% of patients, while 42.4% had no wall thickening. Septations were identified in most lesions (72.7%), whereas calcifications were present in only 27.3% of cases. These findings indicate that multilocularity and septations were the most frequent imaging characteristics detected on contrast-enhanced CT.

Figure 4.6: Lesion Characteristics

shows a graphical representation of lesion nature.

Table 4.4: Bosniak Categories

Bosniak Category	Frequency	Percentage
I	2	6.1
II	5	15.2
IIF	6	18.2
III	8	24.2
IV	12	36.4

We used the Bosniak classification (2019) to characterize cystic renal cell carcinoma. Bosniak category IV lesions were most common (36.4%), followed by category III (24.2%). Categories I and II constituted a smaller proportion of the study population.

Table 4.5: Histopathology Findings

Histopathology	Frequency	Percentage
Malignant (cRCC)	20	60.6
Benign	13	39.4

Table 4.5 shows that histopathological examination confirmed cystic renal cell carcinoma in 20 patients (60.6%), while 13 patients (39.4%) had benign lesions.

Explanation of findings:

We selected 33 patients with suspected cystic renal cell lesions for this study and evaluated them with contrast-enhanced computed tomography (CECT). Most patients (33.3%) were aged 46–60 years, followed by those aged 31–45 years (30.3%). Males accounted for 66.7% of the study population, while females accounted for 33.3%. Flank pain was the most common presenting complaint, reported in 20 (60.6%) patients, followed by hematuria in 11 (33.3%), whereas only 2 (6.1%) lesions were detected incidentally. Most patients had no prior renal disease (72.7%) and no family history of renal cell carcinoma (84.8%). Regarding lesion characteristics, 18 (54.5%) lesions measured >4 cm, while 15 (45.5%) measured ≤4 cm. CT imaging showed that 21 (63.6%) lesions were multilocular, 19 (57.6%) had wall thickening, 24 (72.7%) showed septations, and 9 (27.3%) showed calcifications. According to the Bosniak classification, category IV was most common (36.4%), followed by category III (24.2%), indicating a high probability of malignancy in most lesions. Histopathological examination confirmed cystic renal cell carcinoma in 20 (60.6%) patients, whereas 13 (39.4%) lesions were benign. We found 19 TP, 11 TN, 2 FP, and 1 FN when comparing CECT results with histopathological findings. Consequently, 95.0% sensitivity, 84.6% specificity, 90.5% (PPV), 91.7% (NPV), and 90.9% total diagnostic accuracy were attained.

using contrast-enhanced CT. Additionally, histopathological findings and Bosniak classification were significantly correlated ($p < 0.001$), indicating that higher Bosniak categories were strongly associated with malignant cystic renal lesions.

Discussion

The present study showed that most patients (33.3%) were in the 46–60 years age group, followed by the 31–45 years group (30.3%). The results show that cystic renal cell carcinoma was diagnosed more often in middle-aged and older adults. This observation aligns with Angelini et al., who reported that renal cell carcinoma mainly affects those in their 40s to 60s [7]. Similarly, Fateh et al. reported that reasons for the higher incidence of renal cell carcinoma in advancing age are the accumulation of genetic alterations and prolonged exposure to environmental risk factors [8]. In the current study, males comprised 66.7% of the study population, whereas females comprised 33.3%. The higher prevalence among males is consistent with the established sex distribution of renal cell carcinoma in previous studies. Shen et al. reported similar findings, describing RCC as approximately twice as common in males as in females [9]. Likewise, M Ladurner et al. also reported male predominance, attributing it to lifestyle and hormonal differences [10]. Flank pain was a highly common presenting symptom (60.6%), followed by hematuria (33.3%), while only 6.1% of lesions were detected incidentally. These findings agree with Tufano et al., who reported flank pain as the most frequent presenting complaint in patients with eosinophilic solid and cystic renal cell carcinoma [11]. Similarly, Kumar et al. described mild flank pain as the most common presenting symptom, although they also diagnosed some lesions incidentally [12]. Most patients had no previous renal disease (72.7%) and no family history of renal cell carcinoma (84.8%), suggesting that most cystic renal cell carcinoma cases occurred sporadically. These findings align with Verstraeten et al., who concluded that most renal cell carcinomas are sporadic, while hereditary forms account for only a small proportion of cases [13]. More than half of the lesions (54.5%) measured >4 cm, while 45.5% measured ≤ 4 cm; in this cohort, lesions >4 cm constituted a larger proportion of the sample. Larger lesions are more often associated with complex imaging features and are more likely to be malignant. These findings are similar to those of Chung et al., who recommended surgical management of Bosniak III and IV cystic lesions >4 cm because of their increased malignant potential. [14]. The current study showed that 63.6% of lesions were multilocular, 57.6% had wall thickening, 72.7% had septations, and 27.3% had calcifications. Septations represented the most frequent CT finding. These results are comparable with Baytok et al., who reported multilocular cystic masses with enhancing septa as characteristic CT findings of cystic renal cell carcinoma [15]. Similarly, Toda et al. found that multilocularity, enhancing septa, and wall thickening were more reliable indicators of malignancy than calcification alone [16]. Bosniak category IV lesions represented the largest proportion (36.4%), followed by category III (24.2%). These findings indicate that most lesions demonstrated imaging characteristics associated with a high probability of malignancy. Similar findings were reported by Woon et al., who concluded that Bosniak III and IV lesions carry the highest risk of renal cell carcinoma and usually require surgical management [17]. Histopathological examination confirmed malignancy in 60.6% of patients, while 39.4% had benign lesions. The higher proportion of malignant lesions may reflect the inclusion of patients with suspicious Bosniak III and IV lesions. Bellin et al. reported similar results, finding that most complex cystic renal masses evaluated surgically were histopathologically malignant [18]. We assessed a statistically significant correspondence between Bosniak classification and histopathological findings ($p < 0.001$). Higher Bosniak categories were associated with an increased probability of malignancy. This supports the association between higher Bosniak categories and malignant histopathological findings. These outcomes are similar to Akram et al., who found that the risk of malignancy increases progressively from Bosniak category I to category IV and that Bosniak IV lesions have the highest likelihood of malignant pathology [19].

Conclusion

The current study showed sensitivity of 95.0%, specificity of 84.6%, PPV of 90.5%, NPV of 91.7%, and diagnostic accuracy of 90.9%. CECT showed high diagnostic performance in characterizing cystic renal cell carcinoma. Imaging characteristics such as multilocularity, wall thickening, enhancing septations, and higher Bosniak categories (III and IV) were strongly associated with histopathologically confirmed malignant lesions. Additionally, histopathological findings were statistically significantly associated with Bosniak classification ($p < 0.001$). Therefore, contrast-enhanced CT may be an important imaging modality for characterizing complex cystic renal lesions that lead to malignancy, particularly when further evaluation is needed to guide appropriate clinical management and surgical decision-making. The current study had several limitations. First, the study was limited to a single tertiary healthcare setting; therefore, these results may not apply to other clinical settings. Secondly, the small sample size ($n = 33$) may have resulted in imprecise estimates of diagnostic performance and limited the generalizability of the findings because cystic renal cell malignancy is an uncommon type of kidney cancer, and the study duration was limited. Thirdly, only contrast-enhanced computed tomography was evaluated, while other advanced imaging modalities such as MRI and contrast-enhanced USG were not included in comparison.

Recommendations

To further establish the diagnostic accuracy of CECT, future investigations should include larger sample sizes, multicenter involvement, and long-term patient follow-up. Comparative studies evaluating **contrast-enhanced CT with multiparametric MRI and contrast-enhanced ultrasound** are also recommended to establish the most effective imaging approach for cystic renal cell carcinoma. Future multicenter studies with larger sample sizes, standardized protocols, assessment of interobserver variability, and longer-term follow-up are recommended to validate the diagnostic accuracy of CECT in characterizing cystic renal cell malignancy.

Ethical Approval

The study was approved by the Ethical Review Committee of Allied Hospital II, Faisalabad.

Conflict of Interest

The authors declare no conflict of interest.

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Authors' Contributions

Taram Fazal, Taram Fazal : Conceptualization, study design, data collection, histopathological assessment, interpretation of findings, manuscript drafting, critical revision, and final approval.

Taram Fazal ,Fahmida Ansar ,Ahmad Hassan : Study design, histopathological assessment, data curation, literature review, interpretation of findings, manuscript revision, and final approval.

Ajwa Saeed, Aqsa Ali Asghar : Data collection, histopathological assessment, data curation, literature review, manuscript drafting and revision, and final approval.

All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work in accordance with ICMJE authorship criteria.

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