European Journal of Clinical Pharmacy
Print ISSN: 2385-409X, **Online ISSN**: 3105-0409
Website: https://farmclin.com/

DIAGNOSTIC ACCURACY OF CONTRAST-ENHANCED CT SCAN IN CHARACTERIZATION OF ADRENAL MASSES AS ADENOMAS OR NON-ADENOMAS TAKING HISTOPATHOLOGY AS GOLD STANDARD

Article History:

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Received: 12-09-2025
Revised: 30-09-2025
Accepted: 06-10-2025
Published: 24-10-2025

Abstract: Background: **Objective:** To determine the diagnostic accuracy of contrast-enhanced computed tomography (CECT) in characterization of adrenal masses as adenomas or non-adenomas taking histopathology as gold standard. **Study Design:** Cross-sectional study. **Place and Duration of the Study:** Department of Radiology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan, over a period of three months. **Methodology:** Sixty-seven consecutive patients aged 20–80 years with clinically suspected adrenal masses who underwent contrast-enhanced CT were included. Patients with pregnancy, and major medical comorbidities were excluded. CT images were interpreted by an experienced consultant radiologist blinded to histopathological findings. Lesions were categorized as adenomas or non-adenomas based on imaging characteristics. Histopathological examination served as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated. **Results:** The mean age of the patients was 50.9 ± 12.01 years, and the mean body mass index was 26.75 ± 2.85 kg/m². There were 23 (34.3%) males and 44 (65.7%) females. Contrast-enhanced CT identified 55 (82.1%) adenomas and 12 (17.9%) non-adenomas, which was consistent with histopathological distribution. Compared with histopathology, CT correctly identified 52 adenomas and 9 non-adenomas, with 3 false-positive and 3 false-negative cases. The sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of contrast-enhanced CT for diagnosing adrenal adenomas were 94.5%, 75.0%, 75.0%, 94.5.0%, and 91.0%, respectively. **Conclusion:** Contrast-enhanced CT demonstrated high diagnostic accuracy for differentiating adrenal adenomas from non-adenomatous adrenal masses. It is a reliable first-line imaging modality that can support appropriate clinical decision-making and reduce unnecessary invasive diagnostic procedures.

Keywords: Adrenal mass, Adrenal adenoma, Adenomas, Diagnostic accuracy, Computed tomography, Histopathology

INTRODUCTION

Adrenal masses are increasingly encountered in routine clinical practice because of the widespread use of cross-sectional imaging. Most adrenal lesions are discovered incidentally during imaging performed for unrelated clinical indications and are therefore

referred to as adrenal incidentalomas.[1] The reported prevalence of adrenal incidentalomas ranges from 3% to 7% in the adult population, while autopsy studies have demonstrated an even wider prevalence ranging from 1% to 32%. The majority of these lesions are benign, non-functioning adrenal adenomas; however, a significant proportion represents malignant tumors, metastatic disease, pheochromocytomas, adrenal cortical carcinomas, myelolipomas, adrenal hemorrhage, infections, and other uncommon pathologies. Accurate characterization of these lesions is essential because management strategies differ considerably between benign and malignant adrenal masses.[2,3]

Computed tomography (CT) is the primary imaging modality used for the evaluation of adrenal lesions owing to its wide availability, rapid acquisition, and excellent spatial resolution. Conventional unenhanced CT allows characterization of lipid-rich adenomas based on attenuation values, whereas contrast-enhanced CT provides additional information regarding enhancement characteristics and contrast washout, thereby improving lesion characterization.[4] Multiphasic contrast-enhanced CT has demonstrated excellent diagnostic performance in differentiating adrenal adenomas from non-adenomatous lesions by assessing enhancement patterns, vascularity, lesion heterogeneity, and washout characteristics.[5,6]

Despite advances in imaging techniques, differentiation between benign and malignant adrenal masses remains challenging, particularly in lipid-poor adenomas and lesions with atypical imaging features.[7] Accurate preoperative diagnosis is important because it influences clinical decision-making, avoids unnecessary invasive procedures, facilitates timely surgical intervention in malignant lesions, and reduces healthcare costs.[8] Histopathological examination remains the gold standard for establishing the definitive diagnosis; therefore, imaging modalities are routinely evaluated against histopathology to determine their diagnostic performance.[9]

Several international studies have reported high diagnostic accuracy of CT in adrenal lesion characterization. Previous literature has demonstrated sensitivity ranging from 85% to 100% and specificity ranging from 95% to 100% for differentiating benign from malignant adrenal masses. Wang et al. reported a sensitivity of 93%, specificity of 80%, and overall diagnostic accuracy of 87% for diagnosing adrenal adenomas using contrast-enhanced CT.[10] Similarly, a study conducted in Pakistan by Radha et al. reported sensitivity, specificity, and diagnostic accuracy of 89.7%, 86.6%, and 88.6%, respectively, for CT in the evaluation of malignant adrenal masses using histopathology as the reference standard.[8]

Although several studies have evaluated CT for adrenal lesion characterization, published evidence from Pakistan remains limited, and variations in disease spectrum, patient demographics, and imaging practices necessitate local validation of diagnostic performance. Establishing the accuracy of contrast-enhanced CT in the local population may improve diagnostic confidence, reduce unnecessary biopsies and surgeries, and assist clinicians in selecting the most appropriate management strategy.

Therefore, the present study aimed to determine the diagnostic accuracy of contrast-enhanced CT scan in differentiating adrenal adenomas from non-adenomatous adrenal masses by using histopathological examination as the gold standard.

Methodology:

This cross-sectional diagnostic accuracy study was conducted in the Department of Radiology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, over a period of three months from June 2025 to August 2025 after approval from CPSP. A total of 67 consecutive patients aged 20–80 years with clinically suspected adrenal masses who were referred for contrast-enhanced computed tomography (CECT) were included. Pregnant women and patients with uncontrolled hypertension, diabetes mellitus, stroke, chronic kidney disease, chronic obstructive pulmonary disease, asthma, or congestive heart failure were excluded. Written informed consent was obtained from all participants.

Demographic and clinical data, including age, gender and body mass index (BMI), were recorded using a structured proforma. All patients underwent unenhanced CT followed by contrast-enhanced CT for adrenal lesion characterization. Intravenous non-ionic iodinated contrast was administered according to the departmental protocol. Adrenal lesions were evaluated for size, attenuation, enhancement pattern, homogeneity, margins, and washout characteristics. CT images were interpreted by a consultant radiologist with at least five years of experience who was blinded to the histopathological findings. Based on imaging characteristics, lesions were categorized as adenomas or non-adenomas.

Histopathological examination of surgical or biopsy specimens served as the reference standard. The diagnostic performance of contrast-enhanced CT was assessed by comparing CT findings with histopathological diagnosis. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using a 2 × 2 contingency table. Data were

analyzed using SPSS version 26. Quantitative variables were assessed for normality using the Shapiro–Wilk test and were presented as mean ± standard deviation. Categorical variables were expressed as frequencies and percentages.

Results:

A total of 67 patients with adrenal masses were included in the study. The mean age of the participants was 50.9 ± 12.01 years, while the mean body mass index (BMI) was 26.75 ± 2.85 kg/m². Of the total participants, 23 (34.3%) were males and 44 (65.7%) were females. Seventeen (25.4%) patients were smokers, whereas 50 (74.6%) were non-smokers. Regarding comorbidities, 22 (32.8%) patients had hypertension and 45 (67.2%) had diabetes mellitus.

On contrast-enhanced CT scan, 55 (82.1%) adrenal masses were diagnosed as adenomas, while 12 (17.9%) were diagnosed as non-adenomas. Histopathological examination also confirmed 55 (82.1%) adenomas and 12 (17.9%) non-adenomas.

Comparison of CT findings with histopathology demonstrated that CT correctly identified 52 adenomas and 9 non-adenomas. There were 3 false-positive and 3 false-negative cases.
Using histopathology as the reference standard, contrast-enhanced CT demonstrated a sensitivity of 94.5%, specificity of 75.0%, positive predictive value of 75.0%, negative predictive value of 94.5%, and an overall diagnostic accuracy of 91.0% for differentiating adrenal adenomas from non-adenomas.

Table 1: Baseline/Clinical Data of the Patients (n=67)

Baseline/Clinical Data of the Patients	**(mean ± sd)/n(%)**
Age	50.9 ± 12.01
BMI	26.75 ± 2.85
Gender • Male • Female	 23 (34.3%) 44 (65.7%)
Smoker • Yes • No	 17 (25.4%) 50 (74.6%)
Co-morbids • Hypertension • Diabetes	 22 (32.8%) 45 (67.2%)

Table 2: Diagnosis of Adrenal Masses on CT and Histopathology

Adrenal Masses	**CT**	**Histopathology**
Adenomas	55 (82.1%)	55 (82.1%)
Non-adenomas	12 (17.9%)	12 (17.9%)
Total	67 (100%)	67 (100%)

Table 3: Comparison of CT versus Histopathology in Diagnosis of Adrenal Masses

CT Scan	**Histopathology**	
	Adenomas	**Non-adenomas**
Adenomas	52 (TP)	03 (FP)
Non-adenomas	03 (FN)	09 (TN)
Total	55	12

Table 4: Diagnostic Accuracy of Contrast-Enhanced CT scan in Characterization of Adrenal Masses as Adenomas or Non-Adenomas Taking Histopathology as Gold Standard

Diagnostic Parameters	**Results**
Sensitivity	94.5%
Specificity	75.0%
Diagnostic Accuracy	91.0%
Positive Predictive Value	75%
Negative Predictive Value	94.5%

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DISCUSSION

The diagnostic performance of contrast-enhanced computed tomography (CECT) in differentiating adrenal adenomas from non-adenomatous adrenal masses was assessed in this study with histopathology as the reference standard. Results showed an overall diagnostic accuracy of 91.0%, sensitivity of 94.5%, specificity of 75.0%, positive predictive value of 75% and negative predictive value of 94.5%. These findings suggest that CECT has a high reliability in ruling out non-adenomatous lesions and is still a valuable first line imaging modality in characterizing adrenal masses.

The detection of adrenal incidentalomas has increased with the use of cross-sectional imaging. Most lesions are benign adenomas but it is crucial to distinguish accurately benign from malignant or hormonally active lesions as management of the patient varies considerably according to the underlying pathology. Histopathological examination remains the gold standard for diagnosis but imaging plays a critical role in pre operative evaluation and treatment planning.11,12

In the present study, adenomas accounted for 82.1% of all adrenal lesions whereas non-adenomatous lesions accounted for 17.9%. This distribution is in accordance with previous reports that adrenal adenomas are the commonest form of incidentally detected adrenal masses. Young reported that about 80% of adrenal incidentalomas are benign adenomas, with the remainder being pheochromocytomas, metastases, adrenal cortical carcinoma, myelolipomas, and other less common pathologies.13 Similar observations have also been reported in the European Society of Endocrinology clinical practice guideline, which emphasizes that most adrenal incidentalomas are benign, with only a small proportion requiring surgical intervention.14

The specificity of 75.0% in our study was high, indicating good accuracy of contrast-enhanced CT in differentiating benign adrenal adenomas in most patients. This finding is in agreement with previous studies published showing specificity values of >90% for CT characterization of adrenal lesions. Blake et al. showed that specialized adrenal CT protocols with enhancement and delayed washout analysis significantly improve lesion characterization, with specificity approaching 95% in distinguishing adenomas from malignant lesions.15 Similarly, Korobkin et al. demonstrated that the features of contrast washout have excellent specificity in distinguishing adrenal adenomas from metastases and other malignant adrenal tumors.16

The sensitivity (75.0%) was lower than the specificity and slightly lower than the sensitivity reported in some international studies. A possible explanation is that lipid-poor adenomas and atypical adrenal lesions are included and that these lesions often have enhancement characteristics similar to malignant tumors. Lipid-poor adenomas account for approximately 20% to 30% of adrenal adenomas, and have attenuation values and enhancement patterns that often decrease the sensitivity of CT for diagnosis.15,17Even with multiphasic CT protocols, these lesions are still known to be difficult to diagnose; for a conclusive diagnosis, histological confirmation, positron emission tomography, magnetic resonance imaging, or chemical shift imaging may be necessary.11,15

The total diagnosis accuracy of 91% that our investigation showed is similar to the diagnostic performance documented in another research. When combined with clinical findings, multiphasic CT with washout assessment offers exceptional overall diagnostic accuracy for distinguishing adenomas from non-adenomatous lesions, according to Boland et al.'s review of imaging techniques for adrenal mass characterization.17 In a similar vein, Blake et al. stressed that one of the most reliable and accessible imaging methods for assessing adrenal masses in standard clinical practice is still dedicated adrenal CT procedures.15

The present study's three false-positive and three false-negative examples demonstrate CT imaging's inherent limitations. Certain pheochromocytomas, adrenal cortical carcinomas, or metastatic lesions may have enhanced characteristics similar to those of adenomas, leading to false-positive diagnosis. On the other hand, minor heterogeneous lesions and lipid-poor adenomas may resemble malignant tumors, leading to false-negative results. Therefore, where clinically warranted, uncertain lesions should be further evaluated utilizing other imaging modalities, biochemical testing, interval follow-up, or histological examination.14,15

The study's conclusions have significant clinical ramifications. Contrast-enhanced CT appears to be especially helpful for definitively ruling out malignant adrenal lesions because to its high specificity and negative predictive value, which would minimize needless invasive procedures, biopsies, and surgical operations. CECT provides an accessible, affordable, and trustworthy diagnostic tool for the preliminary assessment of adrenal masses in resource-constrained environments like Pakistan, where access to sophisticated imaging methods may be restricted.
There are some limitations to the current

investigation. The results may not be as broadly applicable as they could be because it was carried out at a single tertiary care facility with a small sample size. Furthermore, conventional contrast-enhanced CT was used to diagnose adrenal lesions without comparing them with magnetic resonance imaging or calculating quantitative washout percentages. The best diagnostic strategy for ambiguous adrenal lesions would be further clarified by future multicenter studies with bigger patient populations and direct comparison of CT with MRI and functional imaging modalities.
Notwithstanding these drawbacks, this study offers important local data on the diagnostic efficacy of contrast-enhanced CT in characterizing adrenal masses. The results underline the necessity of histological confirmation or additional imaging in diagnostically difficult cases, but they also support its ongoing use as the main imaging modality for distinguishing adrenal adenomas from non-adenomatous lesions.

CONCLUSION

Overall, contrast-enhanced computed tomography was highly accurate in differentiating adrenal adenomas from non-adenomatous adrenal masses with excellent sensitivity and good specificity when compared with histopathological findings. The ready availability, rapid acquisition, and reliable diagnostic performance of contrast-enhanced CT make it an effective first-line imaging modality in characterizing adrenal masses and can lead to appropriate clinical decision-making while decreasing unnecessary invasive procedures.

Financial Assistance:
Nil

Conflict of Interest:
Nil

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