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Clinical and Laboratory Profiles of Patients with Adrenal Masses: Correlation with Imaging and Histopathological Outcomes

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Abstract **Original Research Article**

Background: The increased use of imaging techniques such as ultrasound, CT, and MRI has led to more frequent detection of adrenal masses, often incidentally. These lesions may be benign or malignant, and may or may not secrete hormones. Accurate differentiation is vital for guiding treatment, from observation to surgery. Combining clinical symptoms, hormonal profiles, imaging features, and histopathology ensures a comprehensive and precise diagnosis. ***Aim:*** To evaluate the clinical and laboratory profiles of patients with adrenal masses and correlate these findings with imaging characteristics and final histopathological outcomes. ***Methods:*** This cross-sectional observational study was conducted at the Department of Radiology and Imaging in collaboration with the Department of Endocrinology and Pathology, Bangladesh Medical University (BMU), Dhaka, over a two-year period. A total of 30 patients with radiologically detected adrenal masses were consecutively enrolled. Detailed clinical evaluation was performed, documenting symptoms including hypertension, Cushingoid features, virilization, skin pigmentation, and other relevant signs suggestive of hormonal activity. Imaging evaluation was carried out using contrast-enhanced computed tomography (CECT), focusing on lesion size, attenuation, enhancement patterns, and associated features. Definitive diagnosis was established through histopathological examination of biopsy or surgically excised specimens. Clinical, laboratory, and imaging findings were systematically analyzed and correlated with the final histopathological diagnosis to evaluate their diagnostic relevance. Statistical analysis included descriptive measures, with a p-value of <0.05 considered statistically significant. ***Results:*** Thirty patients with adrenal masses, with a mean age of 40.9 ± 17.8 years and a male-to-female ratio of 1.3:1. The most common clinical feature was hypertension (43.3%), followed by Cushingoid appearance and skin pigmentation (23.3% each). Elevated serum cortisol was noted in 23.3% of patients, while elevated VMA and potassium levels were seen in 3.3% and 10%, respectively. On CECT, the most frequent diagnoses were adrenal adenoma (50.0%), hyperplasia (13.3%), and adrenocortical carcinoma (10.0%). Histopathological findings confirmed adrenal adenoma in 46.7% and adrenocortical carcinoma in 13.3% of cases. CECT demonstrated strong agreement with histopathology, with a sensitivity of 85.71%, specificity of 100%, and diagnostic accuracy of 96.67%, highlighting its reliability in assessing adrenal lesions when supported by clinical and laboratory evaluations. ***Conclusion*:** Clinical features and hormonal profiles, when combined with CECT imaging, provide significant diagnostic insight into adrenal masses. Histopathological correlation confirms that this integrated approach enhances the accuracy of distinguishing benign from malignant lesions, supporting informed clinical decision-making

Keywords: Adrenal mass, Hormonal profile, Cushingoid appearance, Histopathology, Contrast-enhanced CT, Functional tumor, Adrenocortical carcinoma.

INTRODUCTION

Adrenal masses are a heterogeneous group of lesions that include non-functioning adenomas, hormonally active tumors (such as pheochromocytomas, cortisol-secreting adenomas), infectious or granulomatous lesions, and malignant neoplasms like

adrenocortical carcinoma or metastatic deposits. With the widespread use of high-resolution imaging modalities, particularly contrast-enhanced computed tomography (CT) and magnetic resonance imaging (MRI), the detection of adrenal masses has increased significantly, often as incidental findings—commonly referred to as "adrenal incidentalomas." Studies report an incidental detection rate of 3–7% on abdominal CT scans performed for unrelated reasons [1-3].

Although the majority of adrenal incidentalomas are benign and clinically silent, up to 20% may be either hormonally active or malignant, necessitating further evaluation [4,5]. Functional adrenal tumors can result in distinct clinical syndromes such as Cushing's syndrome (hypercortisolism), primary hyperaldosteronism (Conn's syndrome), or catecholamine excess (pheochromocytoma). These conditions are associated with significant morbidity, including poorly controlled hypertension, metabolic disturbances, and increased cardiovascular risk [6,7].

A comprehensive evaluation of adrenal masses therefore requires a combination of clinical assessment, hormonal analysis, and radiological imaging. Clinical features such as new-onset or treatment-resistant hypertension, Cushingoid facies, muscle wasting, hirsutism, virilization, or skin hyperpigmentation may suggest endocrine activity and guide further biochemical workup. Laboratory investigations commonly include serum cortisol, plasma adrenocorticotropic hormone (ACTH), 24-hour urinary free cortisol, plasma or urinary metanephrines, aldosterone-renin ratio, and serum electrolytes [8,9].

While imaging provides anatomical details, such as lesion size, shape, density, and enhancement characteristics, it does not always definitively distinguish benign from malignant lesions, particularly in non-functioning tumors. Thus, integrating clinical and laboratory data with imaging findings improves diagnostic accuracy and optimizes patient management [10,11].

This study was undertaken to evaluate the clinical presentations and hormonal profiles of patients with adrenal masses and correlate these findings with contrast-enhanced CT (CECT) and histopathological outcomes. By establishing the diagnostic relevance of clinical and biochemical markers in conjunction with imaging features, the study aims to enhance the early detection and characterization of functionally active or malignant adrenal lesions.

METHODS

A descriptive, cross-sectional study was conducted at the Department of Radiology and Imaging in collaboration with the Departments of Endocrinology and Pathology, Bangladesh Medical University (BMU), Dhaka, over a period of two years. A total of 30 patients presenting with adrenal masses detected on imaging were consecutively enrolled following informed consent.

All patients underwent a thorough clinical evaluation, including assessment for signs and symptoms suggestive of hormonal hyperfunction such as hypertension, Cushingoid features, virilization, skin pigmentation, and weight changes. Clinical history and physical examination findings were systematically recorded.

Laboratory investigations were tailored to the clinical presentation and included serum cortisol (baseline and post-dexamethasone), plasma adrenocorticotropic hormone (ACTH), 24-hour urinary free cortisol, urinary metanephrines and catecholamines, aldosterone, renin, and serum electrolytes. These tests were performed using standard automated immunoassay techniques.

Imaging was performed using contrast-enhanced computed tomography (CECT) of the abdomen. Adrenal lesions were evaluated for location, size, attenuation characteristics, enhancement pattern, margins, presence of hemorrhage or necrosis, and local invasion. Imaging findings were documented and interpreted by experienced radiologists blinded to clinical and hormonal status.

All patients subsequently underwent either image-guided biopsy or surgical excision of the adrenal lesion, and samples were sent for histopathological analysis, which served as the reference standard for diagnosis. The correlation between clinical symptoms, biochemical profiles, imaging features, and final histopathology was analyzed using descriptive statistics and cross-tabulation. Statistical significance was assessed using chi-square and Student's t-tests, with a p-value <0.05 considered statistically significant.

Ethical approval for the study was obtained from the Institutional Review Board of BSMMU prior to commencement.

RESULTS

Table-1: Demographic characteristics of the study patients (n=30)

Variables	Number of patients	Percentage (%)
Age group (years)		
9-19	3	10.0
20-29	5	16.7
30-39	7	23.3
40-80	15	50.0
Mean ± SD	40.9±17.8	
Sex		
Male	17	56.7
Female	13	43.3
Male: Female ratio	1. 3: 1	

This table highlights the demographic distribution of the study population. Among the 30 patients with adrenal masses, the mean age was 40.9 ± 17.8 years, ranging from 9 to 80 years. Half (50%) of the participants were over 40 years old, while 23.3% were between 30–39 years. The study showed a slight male predominance, with 56.7% males and 43.3% females, resulting in a male-to-female ratio of 1.3:1.

Table-2: Distribution of the study patients by clinical presentation (n=30)

Cushingoid appearance	7	23.3
Hypertension	13	43.3
Skin pigmentation	7	23.3

Clinical presentations of the patients revealed that 43.3% had hypertension, making it the most common symptom. Cushingoid appearance, suggestive of hypercortisolism, was observed in 23.3% of patients. An equal proportion (23.3%) presented with skin pigmentation, which may be associated with ACTH-dependent conditions.

Table-3: Distribution of the study patients by lab investigations n=30)

VMA		
Elevated (10.77 mg/24 hour)	1	3.3
Normal (<6.8 mg/24 hour)	29	96.7
S. potassium		
Elevated (5.72-5.98 mEq/L)	3	10.0
Normal (3.5-5.5 mEq/L)	27	90.0
S. cortisol		
Elevated (742-1100 nmol/L)	7	23.3
Normal (140-690 nmol/L)	23	76.7

Laboratory investigations showed that 23.3% of patients had elevated serum cortisol levels, indicating possible cortisol-secreting tumors. Elevated serum potassium was noted in 10%, while 3.3% had increased vanillylmandelic acid (VMA), suggestive of catecholamine-secreting tumors like pheochromocytoma.

Table-4: Distribution of Adrenal Lesions by CECT diagnosis (n=30)

Adrenal Adenoma	15	50.0
Adrenal Myelolipoma	2	6.7
Adrenal Metastases	2	6.7
Adrenocortical carcinoma	3	10.0
Neuroblastoma	1	3.3
Hyperplasia	4	13.3
Histoplasmosis	2	6.7
Adrenal tuberculosis	1	3.3
Total	30	100.0

CECT imaging identified adrenal adenoma in 50% of patients, followed by hyperplasia (13.3%), adrenocortical carcinoma (10%), and metastases (6.7%). Less common findings included myelolipoma, histoplasmosis, neuroblastoma, and adrenal tuberculosis.

Table-5: Distribution of Adrenal Lesions by histopathological diagnosis (n=30)

Adrenal Adenoma	14	46.7
Adrenocortical carcinoma	4	13.3
Myelolipoma	1	3.3
Metastases	2	6.7
Neuroblastoma	1	2.9
Adrenal Hyperplasia	5	16.7
Histoplasmosis	2	6.7
Adrenal tuberculosis	1	3.3
Total	30	100.0

Histopathological confirmation revealed adrenal adenoma in 46.7% of cases, followed by adrenal hyperplasia (16.7%) and adrenocortical carcinoma (13.3%). Other lesions included metastases, myelolipoma, neuroblastoma, histoplasmosis, and tuberculosis.

Table-6: Correlation of CECT and histopathological findings in the diagnosis of Malignant and Benign Adrenal lesion (n=30)

CECT findings	Histopathological findings		Total	p-value
	Malignant	Benign		
Malignant	6 (True Positive)	0 (False positive)	6	<0.001
Benign	1 (False negative)	23 (True negative)	24	
Total	7	23	30	
		Values (%)	95% CI	
Sensitivity		85.71%	42.13% to 99.64%	
Specificity		100.00%	85.18% to 100.00%	
Positive Predictive Value		100.00%	54.07% to 100.00%	
Negative Predictive Value		95.83%	78.93% to 99.30%	
Accuracy		96.67%	82.78% to 99.92%	

Comparison between CECT findings and histopathology demonstrated high diagnostic concordance. CECT correctly identified 6 malignant and 23 benign lesions, missing only one malignant case (false negative). Sensitivity was 85.71%, specificity 100%, and diagnostic accuracy 96.67%. The high predictive values and statistically significant agreement ($p < 0.001$) confirm that CECT is a highly reliable modality when integrated with clinical and laboratory data for evaluating adrenal masses.

DISCUSSION

A cross-sectional observational study was conducted at the Department of Radiology and Imaging, Bangladesh Medical University (BMU), Dhaka, over a two-year period. The study aimed to assess the clinical and biochemical profiles of patients with adrenal masses and evaluate their correlation with radiological and histopathological findings. The primary objective was to determine whether specific clinical features and hormonal abnormalities can reliably guide diagnosis and differentiation between benign and malignant adrenal lesions, thus supporting imaging-based diagnosis and clinical decision-making.

A total of 30 patients were evaluated, with a mean age of 40.9 ± 17.8 years, ranging from 9 to 80 years. Half of the patients were aged 40 years or older, reflecting a higher prevalence of adrenal pathology in the middle-aged and elderly population, which is in line with findings reported in prior studies. [1] There was a slight male predominance (56.7%), yielding a male-to-female ratio of 1.3:1. Similar demographic distributions have been reported by Mohamed *et al.,*[8] and Kunjuraman & Chacko [12], who also observed a male predominance in their respective adrenal mass cohorts.

Clinical presentations were varied. Hypertension was the most common feature, present in 43.3% of patients, followed by Cushingoid features and skin pigmentation (each seen in 23.3%). These findings support the known functional variability of adrenal tumors. Functional adenomas, particularly cortisol-producing tumors, often present with Cushingoid appearance, while pheochromocytomas are associated with hypertension due to catecholamine excess.[13] Hyperpigmentation, often associated with elevated ACTH levels in adrenal insufficiency or ectopic ACTH-producing tumors, was also observed in a subset of patients.

Biochemically, serum cortisol was elevated in 7 patients (23.3%), all of whom showed clinical signs consistent with hypercortisolism. This correlation supports the utility of targeted hormonal evaluation when clinical suspicion is high. Only one patient showed elevated urinary VMA, suggestive of a catecholamine-secreting tumor such as pheochromocytoma, although it was rare in this cohort. Serum potassium was elevated in 10% of patients, which may reflect underlying mineralocorticoid excess or adrenal insufficiency, although more detailed analysis (e.g., aldosterone-renin ratio) would be required to confirm this. [14]

CECT findings provided important morphological clues. Adrenal adenoma was the most frequently diagnosed lesion (50%), followed by adrenal hyperplasia (13.3%), adrenocortical carcinoma (10%), and adrenal metastases (6.7%). Less frequent findings included histoplasmosis, myelolipoma, neuroblastoma, and adrenal tuberculosis. The imaging pattern closely matched histopathological findings, with 46.7% confirmed as adenomas and 13.3% as adrenocortical carcinoma, reinforcing the diagnostic reliability of CECT when interpreted with clinical and biochemical support.

The diagnostic accuracy of CECT in differentiating benign from malignant adrenal lesions was high. As per Table 6, CECT showed a sensitivity of 85.71% and specificity of 100%, with an overall diagnostic accuracy of 96.67%. All malignant lesions identified on CECT were confirmed histologically (true positives), while one malignant case was missed (false negative). These findings are consistent with previous studies by Song *et al.,*[15] and Ng *et al.,*[7], which also demonstrated that CECT provides high diagnostic yield, especially when size, enhancement patterns, and washout characteristics are evaluated. The false negative case underscores the importance of correlating imaging findings with clinical and laboratory profiles, especially in tumors that may not show typical radiological features.

This study emphasizes the value of a multi-disciplinary approach to adrenal mass evaluation. Clinical symptoms such as hypertension and Cushingoid appearance, when supported by hormonal assays (e.g., serum cortisol, urinary VMA), and interpreted alongside CT imaging features, significantly enhance diagnostic confidence. Additionally, the histopathological correlation in this study validates the diagnostic utility of combining imaging and laboratory data in real-world clinical settings.

Limitations of the study include the relatively small sample size and limited biochemical profiling beyond cortisol and VMA. Future studies incorporating a larger patient population, longer follow-up, and more comprehensive hormonal assessments (aldosterone, renin, metanephros's, and DHEAS) would be valuable in further stratifying risk and refining diagnostic algorithms.

CONCLUSION

The present study assesses the value of a multidisciplinary diagnostic approach in evaluating adrenal masses. Clinical symptoms such as hypertension and Cushingoid features, along with biochemical markers like serum cortisol, contribute meaningfully to lesion characterization. When integrated with CECT imaging, which demonstrated high diagnostic accuracy, these parameters enable more reliable differentiation between benign and malignant adrenal tumors. Histopathology remains essential for definitive diagnosis, but the findings support the use of comprehensive preoperative evaluation to guide timely and appropriate management strategies.

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