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A Case Series on Adrenal Tumors: Clinical Spectrum, Pathological Diversity and the Role of Laparoscopic Adrenalectomy

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Abstract

Adrenal tumors exhibit a broad spectrum of clinical presentations, ranging from asymptomatic incidentalomas to hormonally active lesions causing hypertension, hypokalemia, or symptoms of hormonal excess. This case series is a retrospective study which included 14 patients who underwent laparoscopic adrenalectomy over the last 3 years at our institute. The study included predominantly middle-aged females. Functional tumors constituted 71.4% of cases, including Conn's syndrome (40%), pheochromocytomas (40%), and Cushing's syndrome (20%) of these functional tumors. Pathological diagnoses included adrenocortical adenomas (42.9%), pheochromocytomas (28.6%), and rare lesions such as ganglioneuroma and adrenocortical carcinoma. Larger tumors (>6 cm) demonstrated a higher risk of malignancy and surgical complexity. Laparoscopic adrenalectomy, performed in 85.7% of cases, proved to be a safe and effective approach, with a low conversion rate to open surgery (14.3%) due to vascular complications in complex cases. Perioperative stabilization was critical in functional tumors, particularly in pheochromocytoma patients. 75% of pheochromocytoma patients experienced intraoperative hypotension requiring inotropic support. Postoperative outcomes were favorable, with most complications (78.6%) categorized as minor (Clavien-Dindo grade 0-II). Persistent hypertension was noted in a 3 out of 10 patients, requiring ongoing antihypertensive medications postoperatively. This study underscores the spectrum of clinical presentations, diversity of adrenal pathologies, the importance of a multidisciplinary approach for perioperative stabilization, and the safety and efficacy of laparoscopic adrenalectomy as the standard treatment.

Key Words
Adrenal Tumors, Laparoscopic Adrenalectomy, Functional Tumors, Conn's Syndrome, Cushing's Syndrome, Pheochromocytoma, Adrenocortical Carcinoma, Perioperative Stabilization.

INTRODUCTION

Adrenal tumors constitute a wide spectrum of pathologies and diverse clinical presentations depending on the factors like functionality, size and malignant potential. Adenomas are the most frequently encountered tumors of the adrenal gland, found in 6% of autopsies.[1] 7.1% adenomas are metabolically active and functional.[2] Benign adrenal adenomas that secrete cortisol account for 10% of Cushing's syndrome.[3] Primary aldosteronism (Conn's syndrome) is the leading cause of secondary hypertension, accounting 3% to 13% of hypertensive patients in primary care and 30% of those treated in tertiary care.[4] Aldosterone-producing adenomas tend to cause profound hypertension and hypokalemia than idiopathic adrenal hyperplasia.[5] Usually, hypertension resolves after adrenalectomy, but not in all.[6] Aldosterone-producing adenomas present with hypokalemia in 50%.[7] Approximately 5% of adrenal incidentalomas are found to have pheochromocytoma.[8] Paroxysmal hypertension is the hallmark symptom of pheochromocytoma, and it occurs in 30% to 50% of cases.[9] Adrenocortical carcinoma (ACC) is uncommon, and its incidence is 0.7 to 2 cases per 1 million.[10] 40% to 60% of ACC exhibit hormonal hypersecretion symptoms, most commonly cortisol, which leads to Cushing's syndrome.[11] Tumor size correlates with malignancy risk, found in 4% to 5% of tumors <4 cm, 10% of tumors >4 cm, and 25% of >6 cm.[12] Ganglioneuromas are benign neuroectodermal tumors, which are rare and constitute 0.3% to 2% of adrenal incidentalomas.[13] These are frequently diagnosed in younger patients aged 10 to 29 years.[14] The most common adrenal cysts are pseudocysts (39%) and endothelial cysts (45%).[15] Heterogeneous, thick-walled, >5 cm, or symptomatic cysts should undergo further evaluation and surgical excision.[16] Laparoscopic adrenalectomy is the ideal treatment approach for majority of the adrenal tumors.[17] The transperitoneal approach is often preferred, as it offers superior visualization, and a larger working space than the retroperitoneal approach.[17]

Our case series of 14 adrenal tumors studied retrospectively at our institute, highlights the spectrum of clinical presentations, functional status, and diversity of histopathology. It emphasizes the safety and efficacy of laparoscopic adrenalectomy as the standard approach, and the importance of perioperative stabilization.

METHODOLOGY

This is a retrospective consecutive case series which was conducted at the Urology Department of JSS Medical College and Hospital, Mysuru, Karnataka, India. Our study included all patients who underwent laparoscopic adrenalectomy for adrenal tumors from January 2022 to December 2024. A total of 14 cases were included in our study. The overview of patient demographics, clinical characteristics, and perioperative outcomes were illustrated in the tables given below(Table 1, 2).

Case Details

Case 1: A 36-year-old female presented with pedal edema, facial puffiness, weight gain, amenorrhea, abdominal striae for 10 months, and hypertension (186/120 mmHg). Routine blood and urine investigations were normal. CECT abdomen showed a 3.3 x 2.6 x 3 cm right adrenal adenoma. 8AM serum cortisol was elevated (31.45mcg/dl) suggesting Cushing's syndrome. Patient underwent Laparoscopic right adrenalectomy, after perioperative stabilization by an endocrinologist. Intraoperatively BP remained high (160/100mmHg). Postoperatively electrolytes normalized, and BP stabilized (140/90mmHg) after 1 week. Patient was discharged on POD-7. Histopathology confirmed adrenocortical adenoma.

Case 2: A 71-year-old female patient was asymptomatic and incidentally found to have left adrenal adenoma on ultrasonography during a health check-up. Patient had hypertension, diabetes and hypothyroidism. Routine investigations were normal except hypokalemia (3.1mEq/l). CECT abdomen showed a 1.5 x 1.3 cm left adrenal adenoma (Figure 1). High serum aldosterone (281 ng/dl), low serum

renin (0.56 ng/ml/hr), high aldosterone renin ratio of 503 noted and suggested Conn's syndrome. Laparoscopic left adrenalectomy was performed, after perioperative stabilization by an endocrinologist. Postoperatively, persistent hypokalemia (serum potassium 3.1 mEq/l, 24hrs post procedure) got corrected by POD-2 and she was discharged on POD-3. Histopathology confirmed adrenocortical adenoma.

Case 3: A 31-year-old female patient presented with malaise, tingling and numbness of upper limbs for 9 months. Patient was recently diagnosed to have hypertension. Routine blood and urine investigations were normal except hypokalemia (3mEq/l). CECT abdomen showed a 2.2 x 1.5 x 2.5 cm right adrenal adenoma (Figure 2). High serum aldosterone (57 ng/dl), low serum renin (1.88 ng/ml/hr), high aldosterone renin ratio of 30.3 noted which confirmed Conn's syndrome. Perioperative stabilization was done by Endocrinologist. Patient underwent Laparoscopic right adrenalectomy. Perioperatively patient was normotensive. Postoperatively patient had persistent hypokalemia (serum potassium 3.3 mEq/l) which got corrected by POD-2 and she was discharged on POD-3. Histopathology report confirmed adrenocortical adenoma.

Case 4: A 43-year-old male presented with right loin pain for 2 months. Patient had no comorbidities. Routine blood and urine investigations were normal. CECT abdomen showed a 4.2 x 2.6cm right adrenal adenoma (Figure 3). Hormonal assay was normal. Patient underwent Laparoscopic right adrenalectomy. Intraoperative and postoperative period was uneventful. He was discharged on POD-4. Histopathology confirmed adrenocortical adenoma.

Case 5: A 44-year-old female presented with restlessness, fatigue, menorrhagia, hot flashes, excessive diaphoresis for 12 months and hypertension. She had persistent hypokalemia (3 to 3.2mEq/l). CECT abdomen showed a 1.7 x 1.8 cm left adrenal adenoma (Figure 4). High serum aldosterone (43.4 ng/dl), low serum renin (0.41 ng/ml/hr), high aldosterone renin ratio of 106 noted suggesting Conn's syndrome. Preoperatively patient's BP was high (160/100mmHg). Patient underwent Laparoscopic left adrenalectomy, after perioperative stabilization by an endocrinologist. Postoperatively patient had persistent hypertension (158/104mmHg) and persistent hypokalemia (serum potassium 3.2 mEq/l), which got stabilized after 1 week. She was discharged on POD-11. Histopathology confirmed adrenocortical adenoma.

Case 6: A 29-year-old female presented with right lank pain for 4 weeks and with no known comorbidities. Routine blood and urine investigations were normal. CECT abdomen showed a 6 x 5.4 x 7.7cm right adrenal tumor with calcification specks and suspected malignancy features (Figure 5A). Hormonal assay was normal. Patient underwent Laparoscopic right adrenalectomy (Figure 5B). Intraoperative and postoperative periods were uneventful. She was discharged on POD-4. Histopathology showed adrenal ganglioneuroma.

Case 7: A 53-year-old female presented with right lank pain for 5 days and with no known comorbidities. Routine blood and urine investigations were normal. CECT abdomen showed a 2.6 x 2.4 cm right adrenal adenoma. Hormonal assay was normal. Patient underwent Laparoscopic right adrenalectomy. Intraoperative and postoperative periods were uneventful. She was discharged on POD-3. Histopathology showed adrenal paraganglioma.

Case 8: A 42-year-old male presented with left flank pain, excessive diaphoresis, palpitations for 1 month and with hypertension. Routine blood and urine investigations were normal. CECT abdomen showed a 3.2 x 3.7cm left adrenal mass with central necrosis (Figure 6A). Hormonal analysis showed high plasma free normetanephrine (232ng/l) and elevated 24hr urinary VMA (22.4mg/day) suggesting pheochromocytoma. Preoperatively patient had persistent hypertension (170/110mmHg). Patient underwent Laparoscopic left adrenalectomy (Figure 6B), after perioperative stabilization by an endocrinologist. Intraoperatively patient had hypotension (80/54mmHg) and was stabilized by fluid resuscitation and inotropes. She was discharged on POD-6. Histopathology confirmed adrenal pheochromocytoma.

Case 9: A 47-year-old female presented with refractory hypertension for 1 month. Routine blood and urine investigations were normal. CECT abdomen showed a 1.2 x 1.1 cm left adrenal mass (Figure 7). High serum aldosterone (176ng/dl), low serum renin (0.3ng/ml/hr), and high ARR ratio noted suggesting Conn's syndrome. Preoperatively patient had persistent hypertension (170/110mmHg). Patient underwent Laparoscopic left adrenalectomy, after perioperative stabilization by an endocrinologist. Intraoperatively patient had hypertension (170/100mmHg), which got stabilized by POD-2. He was discharged on POD-3. Histopathology confirmed adrenocortical adenoma.

Case 10: A 72-year-old male presented with a cystic lesion in right suprarenal area on ultrasonography as a part of general health checkup. Patient was asymptomatic and hypertensive. Routine blood and urine investigations were normal. CECT abdomen showed an 8 x 5 x 4.4 cm right adrenal cystic mass with peripheral wall calcifications. Hormonal analysis was normal. Patient underwent Laparoscopic right adrenalectomy. Intraoperative and postoperative periods were uneventful. He was discharged on POD-4. Histopathology showed a benign adrenal pseudocyst.

Case 11: A 75-year-old female presented with giddiness and malaise for 1 month and was a hypertensive. Routine blood and urine investigations were normal. CECT abdomen showed a 5.2 x 4.9 x 5 cm right adrenal lesion. Hormonal analysis showed high plasma free metanephrine (104ng/l), high plasma free normetanephrine (199ng/l), and elevated 24hr urinary VMA (18.8mg/day) suggesting pheochromocytoma. Preoperatively patient had elevated blood pressure (140/90mmHg). After stabilization by an endocrinologist, she underwent laparoscopic right adrenalectomy, which was converted to open surgery due to high tumor vascularity and significant intraoperative bleeding. Patient was stabilized with inotropes, oxygen support for intraoperative hypotension (90/40mmHg) and desaturation. Postoperatively anemia (7.6g/dl) was corrected by blood transfusion. She was discharged on POD-7. Histopathology confirmed adrenal pheochromocytoma.

Case 12: A 50-year-old female presented with left flank pain, generalized edema for 4 months and hypertension. Routine blood and urine investigations were normal. CECT abdomen showed a 11.9 x 8.7 x 10.9 cm left adrenal tumor with suspicion for malignancy. Hormonal analysis showed elevated 8AM serum Cortisol (26.9mcg/dl) and low ACTH (1.6pmol/L) suggesting Cushing's syndrome. After stabilization by an endocrinologist, she underwent a laparoscopic left adrenalectomy, which was converted to open surgery due to the tumor abutting the left renal vein. The vein was injured during dissection, leading to continuous bleeding. But there was no significant drop in hemoglobin. Postoperative period was uneventful. She was discharged on POD-6. Histopathology confirmed adrenocortical carcinoma (pT3 stage). Patient is under regular follow-up and is doing well.

Case 13: A 46-year-old female presented with excessive tiredness for 1 month. Routine blood and urine investigations were normal. CECT abdomen showed a 4 x 3.5 x 4.2cm left adrenal tumor. Hormonal analysis showed high plasma free metanephrine (82.5ng/l), high plasma free normetanephrine (178ng/l), and elevated 24hr urinary VMA (17.3 mg/day) suggesting pheochromocytoma. Preoperatively blood pressure was normal. After stabilization by an endocrinologist, she underwent laparoscopic left adrenalectomy (Figure 8). Intraoperative and postoperative periods were uneventful. She was discharged on POD-5. Histopathology confirmed adrenal pheochromocytoma.

Case 14: A 27-year-old male presented with persistent hypertension for 6 months. Routine blood and urine investigations were normal. CECT abdomen showed a 4.6 x 5 x 4cm right adrenal tumor. Hormonal analysis showed high plasma free metanephrine (145ng/l), high plasma free normetanephrine (231ng/l), and elevated 24hr urinary VMA (29.5 mg/day) suggesting pheochromocytoma. Preoperatively blood pressure was persistently high (upto 250/140mmHg). She underwent laparoscopic right adrenalectomy, after perioperative stabilization by an endocrinologist. Intraoperatively she had hypotension and was stabilized using fluid resuscitation and inotropes. He was discharged on POD-6. Histopathology confirmed adrenal pheochromocytoma.

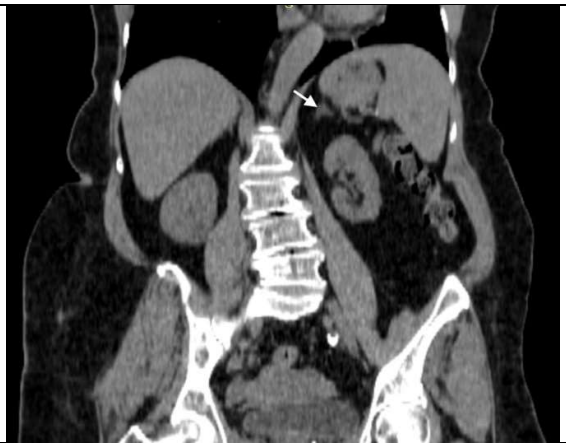

Figure 1: CECT abdomen showing left adrenal lesion (white arrow)

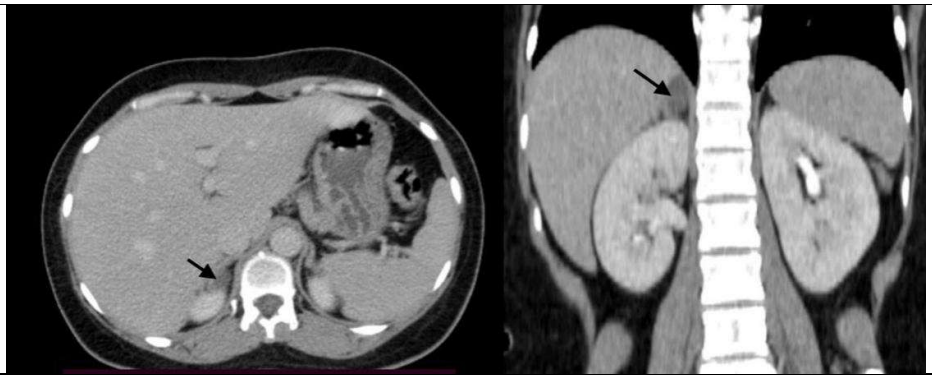

Figure 2: CECT abdomen showing right adrenal lesion (black arrows)

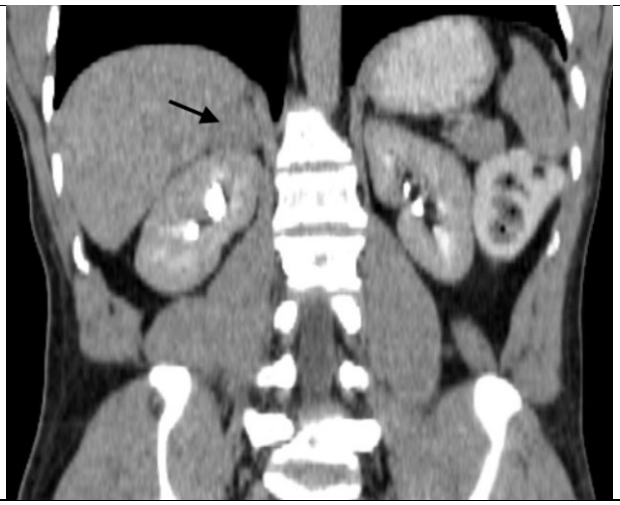

Figure 3: CECT abdomen showing right adrenal lesion (black arrow)

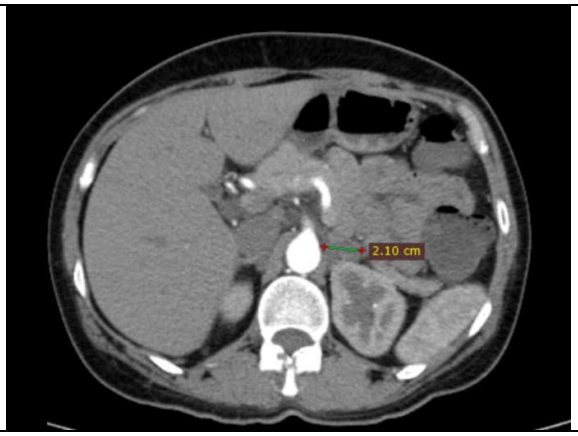

Figure 4: CECT abdomen showing left adrenal lesion

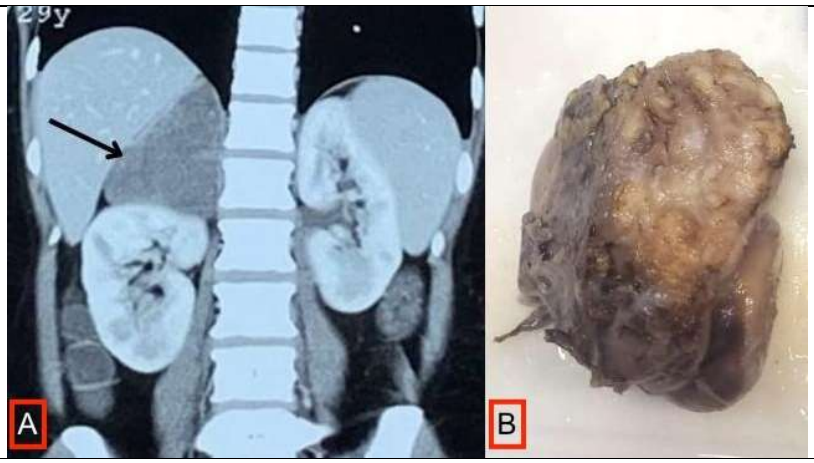

Figure 5: A) CECT abdomen showing large right adrenal lesion (black arrow), B) Gross specimen of ganglioneuroma with cut-section

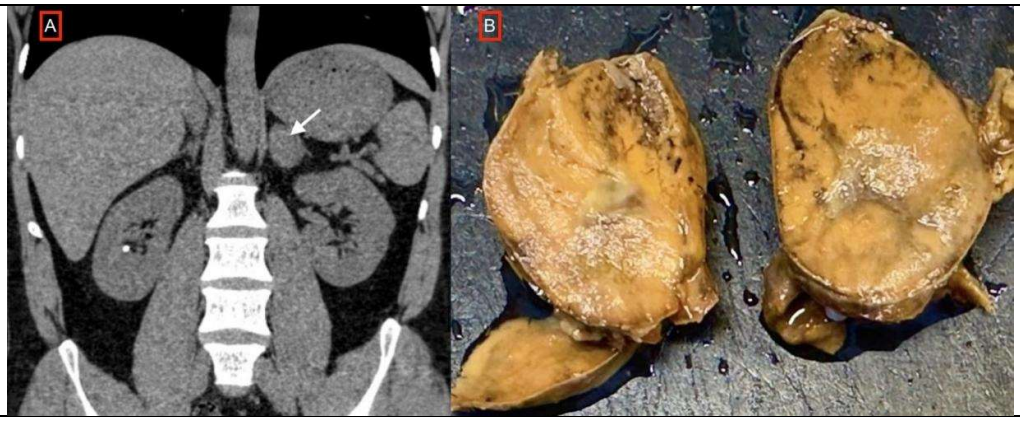

Figure 6: A) CECT abdomen showing left adrenal lesion (white arrow), B) Gross specimen of pheochromocytoma with cut-section

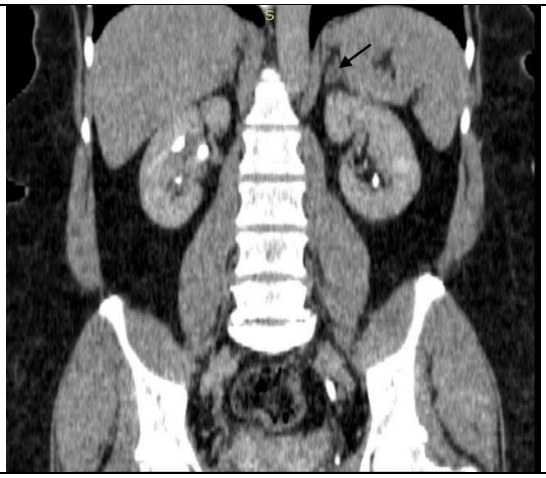

Figure 7: CECT abdomen showing left adrenal lesion (black arrow)

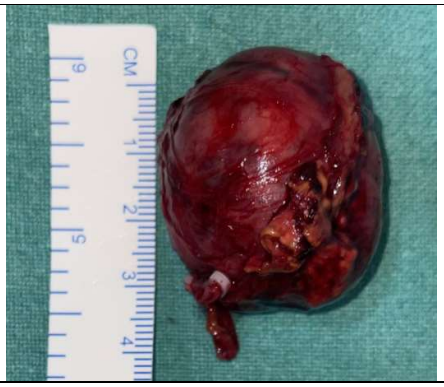

Figure 8: Gross specimen of pheochromocytoma

Pt	Age (year)	Gender	Symptoms	Associated conditions	Laterality	Tumor size(largest dimension)	Endocrine disorder	Functionality	Adrenalectomy	Operative time(min)	Clavien-Dindo grade	Post-op hospital stay (days)	Histopathological diagnosis
1	36	Female	Symptomatic	HTN	Right	3.3cm	Cushing Syndrome	Functional	Lap	150	II	8	Adrenocortical Adenoma
2	71	Female	Asymptomatic	HTN, DM	Left	1.5cm	Conn's Syndrome	Functional	Lap	145	II	4	Adrenocortical Adenoma
3	31	Female	Symptomatic	HTN	Right	2.5cm	Conn's Syndrome	Functional	Lap	145	II	4	Adrenocortical Adenoma
4	43	Male	Symptomatic	No	Right	4.2cm	No	Non-Functional	Lap	110	0	5	Adrenocortical Adenoma
5	44	Female	Symptomatic	HTN	Left	1.8cm	Conn's Syndrome	Functional	Lap	135	II	12	Adrenocortical Adenoma
6	29	Female	Symptomatic	No	Right	7.7cm	No	Non-Functional	Lap	140	0	5	Adrenal Ganglioneuroma
7	53	Female	Symptomatic	No	Right	2.6cm	No	Non-Functional	Lap	110	0	4	Adrenal Paraganglioma
8	42	Male	Symptomatic	HTN	Left	3.7cm	Pheochromocytoma	Functional	Lap	185	IV	7	Adrenal Pheochromocytoma

9	47	Female	Asymptomatic	HTN	Left	1.2cm	Conn's Syndrome	Functional	Lap	195	0	4	Adrenocortical Adenoma
10	72	Male	Asymptomatic	HTN, DM	Right	8cm	No	non-Functional	Lap	120	0	5	Adrenal Pseudocyst
11	75	Female	Symptomatic	HTN, DM	Right	5.2cm	Pheochromocytoma	Functional	Lap to Open	270	IV	8	Adrenal Pheochromocytoma
12	50	Female	Symptomatic	HTN, DM	Left	11.9 cm	Cushing Syndrome	Functional	Lap to Open	195	I	7	Adrenocortical Carcinoma
13	46	Female	Symptomatic	No	Left	4.2cm	Pheochromocytoma	Functional	Lap	180	0	6	Adrenal Pheochromocytoma
14	27	Male	Symptomatic	HTN	Right	5cm	Pheochromocytoma	Functional	Lap	220	IV	7	Adrenal Pheochromocytoma

Table 1: This table illustrates the overview of patient demographics and clinical characteristics

Parameters	Frequency
Age group (years)	
21-40	4
41-60	7
>60	3
Tumor size (largest dimension)	
Up to 4cm	7
4.1 – 6cm	4
>6cm	3
Elevated hormones	
8AM serum cortisol	2
Serum aldosterone	4
Plasma free metanephrines	3
Plasma free normetanephrines	4
24hr urinary VMA	4
Serum DHEAS	0
Other parameters	
Operative time (min)(mean)	164.3
Postoperative Hospital stay (days)(mean)	6.14
Blood transfusion (n)	1

Table 2: This table illustrates the age groups, tumor size, elevated hormones, and perioperative outcomes

DISCUSSION

Adrenal tumors are lesions with wide spectrum of clinical presentations and diverse pathological diagnoses. Adrenal lesions can be functional or non-functional. Our case series of 14 laparoscopic adrenalectomy patients provide important insights into the clinical spectrum, diagnosis, surgical management, and outcomes of adrenal lesions. Our findings were compared with global trends, reinforcing the efficiency of laparoscopic adrenalectomy as the preferred surgery in majority of the cases.

In our series, patients were mostly female (71.4%) and aged 41–60 years (50%), with the remaining distributed between the 21–40 years (28.5%) and >60 years (21.5%) age groups. These findings coincide with global data showing middle-aged women with a higher incidence of adrenal masses.[17]

Out of 14 patients, 78.6% (11 patients) were symptomatic, presenting with hypokalemia, hypertension, or other features of hormonal overproduction, whereas 21.4% (3 patients) were asymptomatic. The most associated condition was hypertension, affecting 71.4% (10 patients). Frequent association of functional adrenal tumors is hypertension, especially pheochromocytoma and Conn's syndrome, which cause secondary hypertension.[4,9]

In our series, adrenal masses were common on the right side (57.1%) compared to the left

(42.9%). This finding aligns with some studies reporting a slight predilection for right-sided adrenal masses, though it is not always statistically significant.[18]

Majority of these tumors were functional (71.4%, 10 patients), with the distribution as 4 cases (40%) of Conn's syndrome, 2 cases (20%) of Cushing's syndrome, and 4 cases (40%) of pheochromocytoma amongst these functional tumors. These findings are coinciding with global trends, where Conn's syndrome is one of the most common functional adrenal disorders, affecting 30–60% of cases with functional adrenal lesions.[19] Rest of the 4 cases (28.6%) were non-functional. In our case series, 5 cases (83%) out of 6 adrenal adenomas were functional, which contrasts with the literature showing 7.1% of adenomas were functional.[2]

In our series, adrenal tumors were of various sizes, 50% (7 cases) were ≤4 cm, 28.6% (4 cases) were 4.1–6 cm, and 21.4% (3 cases) were >6 cm. Larger tumors (>6 cm) included a ganglioneuroma, an adrenocortical carcinoma, and a pseudocyst, are consistent with the literature that >6 cm adrenal tumors have a higher risk of malignancy.[12] Although the ganglioneuromas are rare, they would mimic malignancy and should be considered as a differential diagnosis in a larger tumor.

The histopathological diagnoses included 42.9% (6 cases) adrenocortical adenomas and 28.6% (4 cases) pheochromocytomas. Our series also included 7.1% (1 case) each of ganglioneuroma, paraganglioma, pseudocyst, and an adrenocortical carcinoma. This distribution reflects the global trends in the prevalence of adrenal pathologies, where adrenal adenomas are the most common and adrenocortical carcinomas rare (2–5%).[20]

The case of adrenocortical carcinoma in our series was associated with Cushing's syndrome. This finding is consistent with the literature, which reports that 40% to 60% of ACC cases were associated with Cushing's syndrome.[11]

The primary treatment approach was Laparoscopic adrenalectomy, done in 12 cases (85.7%), with 2 cases (14.3%) converted to open procedure due to complications intraoperatively. In a 5.2cm adrenal pheochromocytoma case, intraoperatively there was significant bleeding due to high tumor vascularity during dissection and had hypotension, patient was stabilized with fluid resuscitation, blood transfusion and inotropic support. In another case of adrenocortical carcinoma, tumor mass was abutting the left renal vein, which got injured during dissection and continuous uncontrolled intraoperative bleeding noted. In both these cases, procedure was converted to open surgery.

The mean duration of surgery was 164.3 minutes, which is comparable to global trends of 150–180 minutes for laparoscopic adrenalectomy procedure.[21] The mean postoperative hospital stay was 6.14 days, denoting a slightly longer stay due to management of complications and perioperative stabilization.

In our case series, 3 out of 4 patients with Conn's syndrome presented with preoperative hypokalemia, which gradually normalized following adrenalectomy. Hypertension was noted in 10 patients preoperatively; among them, persistent hypertension was seen in 3 patients (one with Cushing's syndrome, one with Conn's syndrome, and one with a pseudocyst) who required ongoing antihypertensive medications postoperatively. In the patient with a pseudocyst, the hypertension was likely due to essential hypertension. In the other two cases (Cushing's syndrome and Conn's syndrome), the need for ongoing antihypertensive medications was likely because of the adrenal pathologies on arterial function before surgery.

3 out of 4 patients with pheochromocytoma had hypotension intraoperatively, requiring inotropic support for stabilization.

Only 1 patient underwent blood transfusion, showing low perioperative blood loss associated with laparoscopic adrenalectomy. Complications were minimal and categorized using the Clavien-Dindo system with 6 cases (42.9%) of grade 0, 1 case (7.1%) of grade I, 4 cases (28.6%) of grade II, and 3 cases (21.4%) of Grade IV. The grade IV complications occurred in patients with pheochromocytomas who required postoperative ICU care for hypotension management and monitoring. Notably, intraoperative hypotension in pheochromocytoma cases is related to the nature of the disorder itself rather than the surgical approach, whether laparoscopic or open. These findings highlight the overall safety of laparoscopic adrenalectomy, importance of perioperative stabilization while acknowledging the inherent risks associated with pheochromocytomas.

Our findings are consistent with international trends in adrenal tumors. The predominance of Conn's syndrome is in line with global reports.[22] The high success rate of laparoscopic adrenalectomy (85.7%) mirrors global conversion rates of 5–20%.[23] The low complication rate supports the safety of

minimally invasive surgery for adrenal tumors.[24]

CONCLUSION

This case series underscores the spectrum of clinical presentations, functional status, and diversity of histopathology of adrenal tumors. Laparoscopic adrenalectomy proved to be a safe and effective approach, with a low conversion rate to open surgery due to intraoperative challenges. Functional tumors, particularly Conn's syndrome, were predominant, and consistent with global trends. Larger tumors (>6 cm) posed higher risks for malignancy and surgical complications. Successful outcomes relied on comprehensive preoperative evaluation, meticulous perioperative management, and a multidisciplinary approach involving urologists, endocrinologists, and anesthetists. Our findings support laparoscopic adrenalectomy as the standard of care for most adrenal lesions, with open surgery reserved for select cases involving large or invasive tumors. Continued research and larger studies are essential to optimize surgical strategies and enhance patient care.

Conflict of Interest: None

Statement in financial support: None

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