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Case Series

Assessment of Intraoperative and Technical Difficulties Associated with Laparoscopic Adrenalectomy in Patients with Adrenal Pheochromocytoma: A Case Series Study

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Abstract

Background: Pheochromocytomas are rare catecholamine-producing adrenal tumors that pose significant perioperative challenges due to their potential for sudden hypertensive crises and arrhythmias. Laparoscopic adrenalectomy has emerged as the gold standard approach, offering advantages of reduced postoperative morbidity, shorter hospital stay, and faster recovery compared to open surgery. However, in the context of pheochromocytoma, the procedure remains technically demanding because of intraoperative hemodynamic instability, tumor size, bilateral involvement, and close relation to vital vascular structures.

Objective: To evaluate the intraoperative and perioperative challenges faced during laparoscopic adrenalectomy for adrenal pheochromocytoma and to analyze strategies that improve surgical and anesthetic outcomes.

Methodology: This retrospective case-based study, conducted from January 2024 to October 2024, evaluated five patients with biochemically and radiologically confirmed pheochromocytomas who underwent laparoscopic adrenalectomy following preoperative alpha-blockade and additional antihypertensive therapy where required.

Result: Tumor dimensions ranged from 3.5 to 5.1 cm. Two patients experienced intraoperative hypertensive surges, which were controlled with anesthetic support. Larger tumors (>4 cm) and those adherent to the inferior vena cava and liver presented greater technical challenges due to loss of fat planes and bleeding risk. One patient with bilateral pheochromocytoma underwent unilateral adrenalectomy to reduce operative risk while achieving tumor control. All procedures were completed laparoscopically without conversion to open surgery, and histopathology confirmed pheochromocytoma in every case. Our findings highlight that while laparoscopic adrenalectomy is safe and feasible, it requires meticulous preoperative optimization, vigilant intraoperative monitoring, and skilled surgical technique to overcome challenges related to tumor size, vascular proximity, and endocrine fluctuations. In experienced hands and multidisciplinary settings, laparoscopic adrenalectomy remains the preferred approach for pheochromocytomas up to 6 cm, ensuring favorable outcomes with minimal morbidity.

Keywords: Pheochromocytoma; Laparoscopic Adrenalectomy; Hemodynamic Instability; Adrenal Tumor; Minimally Invasive Surgery; Hypertension; Adrenalectomy Challenges.

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Introduction

Pheochromocytomas are rare catecholamine-producing tumors of chromaffin cells, with an estimated annual incidence of 0.8 per 100,000 population. [1] They account for less than 0.2% of all cases of hypertension, but due to their paroxysmal and potentially lethal cardiovascular manifestations, their management remains clinically significant. Patients often present with symptoms such as palpitations, episodic headaches, sweating, and hypertension. Biochemical

confirmation is obtained by elevated plasma or urinary metanephrines, while imaging with CT or MRI helps in localization. [2] Traditionally, open adrenalectomy was the standard surgical approach, but since Gagner et al. first reported laparoscopic adrenalectomy in 1992, it has become the gold standard for most adrenal pathologies, including pheochromocytomas. [3] The laparoscopic approach offers reduced postoperative pain, shorter hospital stay, and quicker recovery. [4] However, pheochromocytomas pose unique challenges during laparoscopy due to intraoperative hemodynamic instability, tumor size, location, and proximity to vital structures. This study evaluates our experience with laparoscopic adrenalectomy for pheochromocytomas and discusses the intraoperative challenges encountered. [5]

Methodology

This is a retrospective case-based study conducted between January 2024 and October 2024. Five patients with biochemically and radiologically confirmed adrenal pheochromocytomas underwent laparoscopic adrenalectomy at our institution.

Inclusion Criteria:

- Patients with CT/MRI evidence of adrenal mass suspicious for pheochromocytoma
- Biochemical confirmation with plasma-free metanephrines/normetanephrines
- Patients optimized preoperatively with alpha-blockers ± beta-blockers

Preoperative Optimization: All patients received alpha blockade (prazosin), and where required, beta-blockers or calcium channel blockers were added to control hypertension and prevent intraoperative cardiovascular events.

Surgical Technique: All adrenalectomies were performed laparoscopically using the transperitoneal approach. Patients were placed in a lateral decubitus position. Ports were inserted in standard triangulated fashion, and the adrenal gland was mobilized carefully to minimize tumor handling. Dissection was performed using harmonic scalpel and energy devices. Hemodynamic parameters were closely monitored by the anesthetic team throughout the procedure.

Results

Five patients underwent laparoscopic adrenalectomy during the study period. The clinical and surgical details are summarized below:

Case 1: A 47-year-old male presented with a left adrenal pheochromocytoma measuring 4.1 × 3.4 × 5.1 cm. The tumor was well defined without invasion of adjacent structures. The procedure lasted 140 minutes with an estimated blood loss of 150 mL, and the excised specimen weighed 65 g. Intraoperative hypertensive surges were noted but effectively controlled with anesthetic measures. The surgery was completed laparoscopically without complications.

Case 2: A 25-year-old male with a right adrenal pheochromocytoma measuring 3.5 × 2.4 × 2.9 cm underwent laparoscopic adrenalectomy. The operative duration was 120 minutes, with minimal blood loss of approximately 100 mL. The specimen weighed 45 g. The surgery proceeded smoothly with only minor fluctuations in blood pressure. The postoperative course was uneventful.

Case 3: A 36-year-old male was diagnosed with bilateral pheochromocytomas, with the right adrenal tumor measuring 3.7 × 3.5 cm and two left adrenal tumors measuring 2.4 cm and 1.4 cm. Right adrenalectomy was performed due to larger size and mass effect. The surgery lasted 180 minutes with an estimated blood loss of 200 mL, and the specimen weighed 70 g. Dissection was technically demanding as the tumor was abutting the IVC, duodenum, and hepatic flexure, but the procedure was completed laparoscopically.

Case 4: A 49-year-old female presented with a right adrenal pheochromocytoma measuring 4.6 × 3.4 cm, complicated by adrenal hemorrhage.

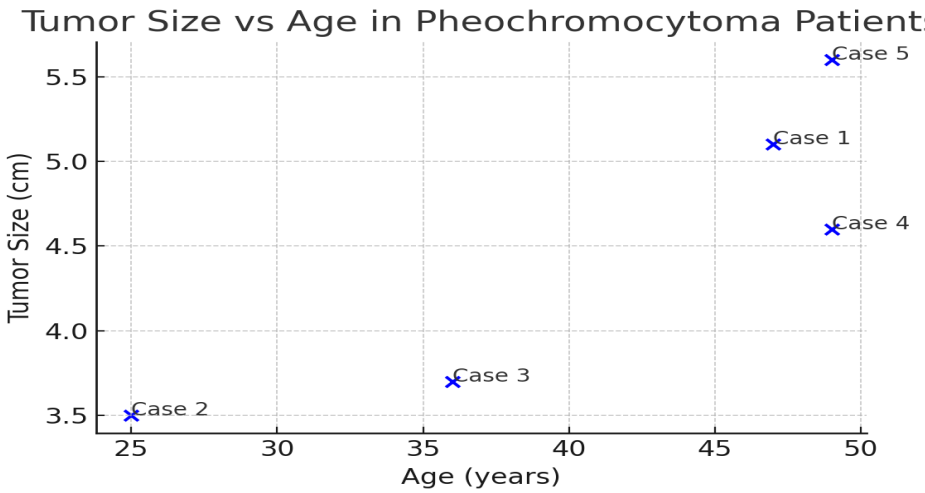
The operative duration was 160 minutes, with blood loss estimated at 250 mL, and the specimen weighed 80 g. The tumor was adherent to the IVC and adjacent liver with loss of fat planes, which made dissection technically demanding. Intraoperative bleeding was controlled, and the adrenalectomy was completed laparoscopically.

Case 5: A 49-year-old female had a left adrenal mass measuring 5.6 × 3.8 × 3.5 cm, which was heterogeneously enhancing with solid and cystic components.

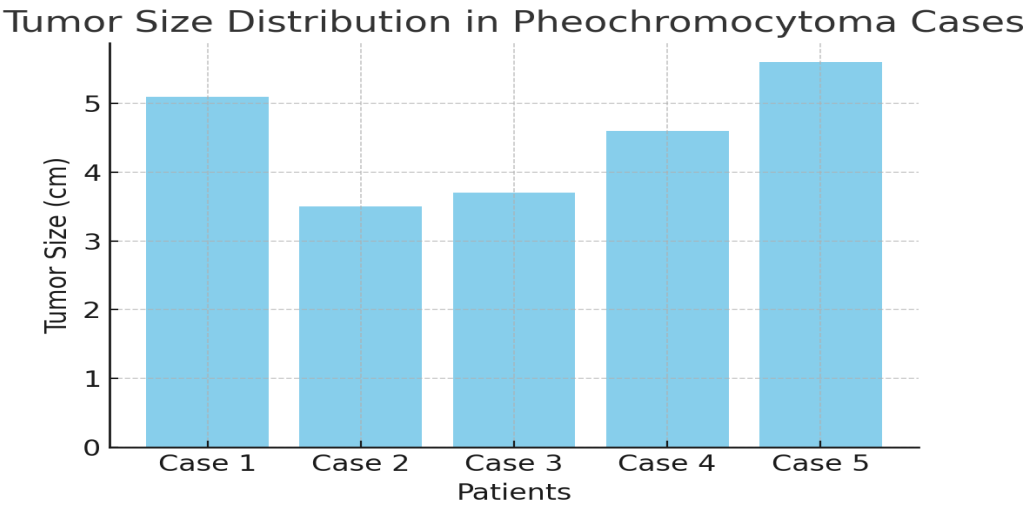
The lesion abutted the upper pole of the kidney with loss of fat planes, and bilateral intrarenal calculi were also noted. The surgery lasted 170 minutes with an estimated blood loss of 300 mL, and the excised specimen weighed 95 g. The laparoscopic adrenalectomy was technically demanding but completed successfully following adequate preoperative optimization.

Table 1: Clinical and Perioperative Details of Patients with Adrenal Pheochromocytoma

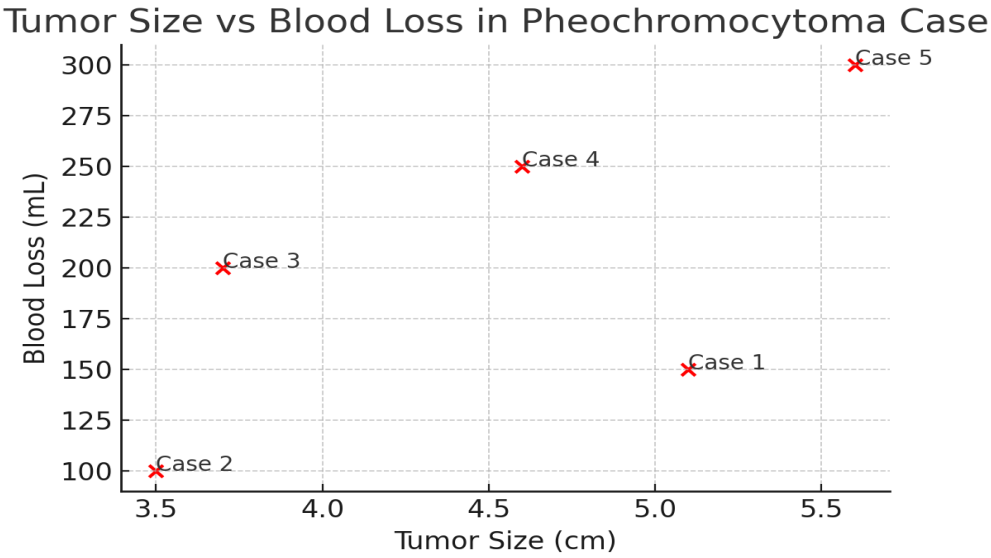
Case	Age / Sex	Location	Tumor Size (cm)	Duration (min)	Blood Loss (mL)	Specimen Weight (g)	Intraoperative / Surgical Challenges	Outcome
1	47 / M	Left	4.1 × 3.4 × 5.1	140	150	65	Hypertensive surges, controlled with anesthesia	Completed laparoscopically
2	25 / M	Right	3.5 × 2.4 × 2.9	120	100	45	Minor BP fluctuations	Completed laparoscopically
3	36 / M	Right	Bilateral (Rt 3.7 × 3.5; Lt 2.4 & 1.4)	180	200	70(rt side)	Proximity to IVC, duodenum, hepatic flexure	Right adrenalectomy performed laparoscopically
4	49 / F	Right	4.6 × 3.4	160	250	80	Hemorrhagic tumor, adherent to IVC & liver	Completed laparoscopically
5	49 / F	Left	5.6 × 3.8 × 3.5	170	300	95	Solid-cystic mass, loss of fat planes, abutting kidney, bilateral renal calculi	Completed laparoscopically



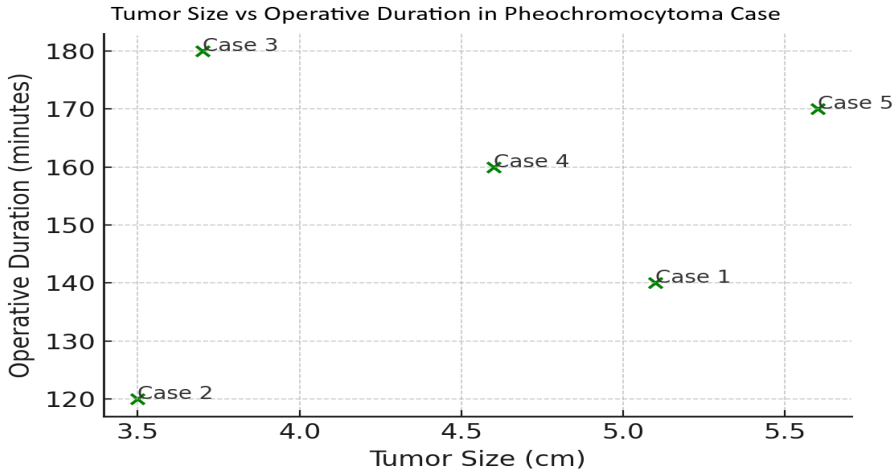
Graph 1: Tumor Size Distribution



Graph 2: Age vs Tumor Size



Graph 3: Tumor size vs Blood loss



Graph 4: Tumor Size vs Operation time duration

Graph 1: Tumor Size Distribution

- This scatter plot demonstrates the relationship between patient age and maximum tumor dimension.
- The analysis shows no linear correlation between age and tumor size, as both younger (25 years) and older patients (49 years) presented with moderate-to-large tumors (3.5–5.6 cm).
- The largest tumor (5.6 cm) was seen in a 49-year-old female (Case 5), while the smallest tumor (3.5 cm) was in a 25-year-old male (Case 2).

Graph 2: Age vs Tumor Size

- This bar chart illustrates the tumor size distribution across the five studied cases.
- Tumor dimensions ranged between 3.5 cm and 5.6 cm, with most cases clustering in the 3.5–5.1 cm range.
- Case 5 had the largest tumor (5.6 cm), while Case 2 had the smallest tumor (3.5 cm).
- The distribution highlights that although all cases were managed laparoscopically, tumors >4 cm posed greater technical challenges, especially when associated with vascular proximity and loss of fat planes.

Graph 3: Tumor size vs Blood loss

This chart shows about the blood loss during the procedure. Case 2 had a 100 ml blood loss while Case 5 had about 300 ml blood loss. Total average 200 ml blood loss in laparoscopic adrenalectomy. More blood loss in the Case 5 is may be due to large tumor size of more than 5 cm. Blood loss is also depends on the adhesion of the tumor with other surrounding organs, high blood pressure and dissection.

Graph 4: Tumor Size vs Operation time duration

Graph 4 shows the comparison of the procedure time duration and Tumor Size.

Patients with Tumor size more than 4 cm had more operative time duration as compared to patients who had tumor size less than 4 cm.

However in the case 3 Tumor size is 3.5 cm but the time duration in this case is more than 180 minutes. The reason behind this is that the tumor is compressing major abdominal organs like Inferior Vena cava, Duodenum and hepatic flexure of the large colon and laparoscopic adrenalectomy procedure itself is difficult surgery for the less experience surgeon due to Right and left tumor orientation, instruments handling and hemodynamic instability.

The average time duration for all surgery was154 minutes.

In all cases, laparoscopic adrenalectomy was completed without conversion to open surgery. Histopathology confirmed pheochromocytoma in all patients.

Discussion

Laparoscopic adrenalectomy has revolutionized the management of adrenal tumors, but pheochromocytomas continue to pose unique intraoperative challenges. The primary concern is intraoperative hemodynamic instability. Manipulation of the tumor can trigger sudden catecholamine release, leading to severe hypertension and arrhythmias. Adequate preoperative alpha-blockade remains the cornerstone of preparation, but intraoperative vigilance is equally essential. [6]

Tumor size and location are additional challenges. Tumors larger than 4–5 cm, or those closely abutting vital structures like the inferior vena cava, liver, and diaphragm, increase the risk of bleeding and make dissection more difficult. In our series, three patients had tumors >4 cm with loss of fat planes, requiring meticulous dissection. Intraoperative bleeding is a well-recognized risk; however, no conversions to open surgery were required. [7]

Bilateral pheochromocytomas present further complexity, as cortical-sparing adrenalectomy may be considered to avoid lifelong adrenal insufficiency. In our bilateral case, unilateral adrenalectomy was prioritized to achieve tumor control while minimizing risks. [8]

Compared to open adrenalectomy, the laparoscopic approach significantly reduces postoperative morbidity, length of hospital stay, and recovery time, though it demands high surgical expertise. Robotic adrenalectomy is an emerging alternative that may overcome some technical limitations. [9]

Our findings align with published literature, which supports laparoscopic adrenalectomy as the gold standard for pheochromocytomas up to 6 cm in size, provided the surgery is performed in high-volume centers with multidisciplinary support. [10]

Conclusion

Laparoscopic adrenalectomy for pheochromocytoma is safe and effective but remains technically demanding. Key challenges include intraoperative hypertensive crises, large tumor size, loss of fat planes, and proximity to major vascular structures. Successful outcomes depend on thorough preoperative optimization, vigilant intraoperative monitoring, and meticulous surgical dissection. With an experienced multidisciplinary team, laparoscopy remains the preferred approach for managing adrenal pheochromocytoma.

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