PERIOPERATIVE OUTCOMES OF LAPAROSCOPIC ADRENALECTOMY FOR ADRENAL TUMORS: A SINGLE-CENTER RETROSPECTIVE STUDY

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PERIOPERATIVE OUTCOMES OF LAPAROSCOPIC ADRENALECTOMY FOR ADRENAL TUMORS: A SINGLE-CENTER RETROSPECTIVE STUDY (Abstract): Laparoscopic adrenalectomy has become the preferred minimally invasive approach for most selected adrenal tumors. The evaluation of perioperative outcomes in a university center is essential for assessing the safety, feasibility, and clinical relevance of this technique in routine surgical practice. **Aim:** To assess the perioperative outcomes of laparoscopic adrenalectomy in patients with adrenal tumors treated in a university center. **Materials and methods:** We performed a retrospective single-center study including adult patients with adrenal tumors who underwent laparoscopic adrenalectomy between 2020 and 2025 at Sf. Spiridon County Clinical Emergency Hospital, Iași. Demographic and clinical characteristics, hormonal status, tumor size, perioperative parameters, and final histopathological findings were analyzed. **Results:** The study included 52 patients who underwent 53 laparoscopic adrenalectomies. The mean age was 56.8 years, and 67.3% of patients were female. Non-functioning tumors represented 50.0% of cases. Mean tumor size on preoperative imaging was 4.0 cm, mean operative time was 139.7 minutes, and mean estimated blood loss was 93.6 mL. Conversion to open surgery occurred in 26.4% of procedures and was associated with older age ($p=0.045$), longer operative time ($p<0.001$), greater estimated blood loss ($p<0.001$), prolonged drainage ($p<0.001$), and longer hospital stay ($p=0.013$). Postoperative complications occurred in 9.4% of procedures, and no 30-day mortality was recorded. **Conclusions:** Laparoscopic adrenalectomy is a feasible and safe approach for selected adrenal tumors, providing favorable postoperative outcomes in a university surgical center. **Keywords:** PERIOPERATIVE OUTCOMES, ADRENAL-ECTOMY, ADRENAL TUMORS.

INTRODUCTION

Adrenal tumors represent a heterogeneous group of lesions, including non-functioning masses, hormone-secreting tumors, and lesions with malignant potential. The development and widespread use of modern imaging techniques have led to an increased detection rate of these lesions, many of which are discovered incidentally during investigations performed for other conditions. At present, adrenal incidentaloma is recognized as a frequent entity in clinical practice, requiring a multidisciplinary approach based on the correlation of imaging, endocrine, and surgical data (1-4).

From an anatomical perspective, the ad-

renal glands are paired endocrine organs located in the retroperitoneum, in close relationship with the upper poles of the kidneys, the diaphragm, and the major abdominal vessels. The characteristics of venous drainage are of particular surgical importance: the right adrenal vein is short and drains directly into the inferior vena cava, whereas the left adrenal vein is longer and usually drains into the left renal vein, sometimes together with the inferior phrenic vein. These anatomical differences influence intraoperative exposure, dissection strategy, and hemorrhagic risk, and are essential in the planning and performance of minimally invasive adrenalectomy (5-7).

The biological heterogeneity of adrenal tumors explains the variability of their clinical presentation. Some lesions are completely asymptomatic and are identified incidentally, whereas others manifest through hormonal hypersecretion, producing distinct clinical syndromes such as primary hyperaldosteronism, hypercortisolism, or pheochromocytoma. Current guidelines recommend systematic endocrinological evaluation for all clinically relevant adrenal masses, both to exclude hormonal secretion and to establish the therapeutic indication. Primary hyperaldosteronism, pheochromocytoma, and glucocorticoid hypersecretion syndromes have direct implications for perioperative management and the type of preoperative preparation required (3, 8-11).

Surgical treatment is the main therapeutic option for functioning adrenal tumors, lesions suspicious for malignancy, and certain masses with imaging or size-related risk criteria. Over the last three decades, minimally invasive surgery has profoundly changed the management of adrenal pathology. Since the first laparoscopic adrenalectomy was described by Gagner and colleagues in 1992, the laparoscopic approach has progressively become the therapeutic standard for most selected benign adrenal tumors because of its advantages in terms of reduced postoperative pain, lower blood loss, shorter hospital stay, and faster functional recovery compared with open surgery (12-16).

From a technical point of view, laparoscopic adrenalectomy can be performed through either a transperitoneal or retroperitoneal approach. The transperitoneal approach provides a wide operative field and familiar anatomical landmarks and is preferred in many university centers, whereas the retroperitoneal approach allows direct access to the adrenal lodge without mobilization of intraperitoneal organs and is useful in selected cases. The choice of technique depends on the team's experience, tumor location, patient habitus, and anatomical particularities. Regardless of the route used, the fundamental surgical principles include adequate exposure, early identification and control of the venous pedicle, careful dissection, and adherence to oncological principles in suspicious cases (13, 17-19).

Although laparoscopy is considered the method of choice for most selected benign lesions, the indication must be adapted carefully in cases of large tumors, suspected adrenocortical carcinoma, local invasion, or technically demanding pheochromocytoma. In these situations, case selection and the experience of the surgical center are key determinants of procedural safety. Published data show that the minimally invasive approach can achieve very good results in carefully selected cases; however, open surgery remains the standard in the presence of major oncological suspicion or invasion of adjacent structures (11,20-22).

In this context, the evaluation of perioperative outcomes of laparoscopic adrenalectomy in a university center has both practical and scientific value. The analysis of intraoperative and postoperative parameters, correlated with clinical, imaging, and histopathological data, allows an assessment of the safety, feasibility, and limitations of this technique in real-world practice. At the same time, such data may contribute to optimizing patient selection and comparing local experience with the series reported in the international literature (14-16,18,19).

AIM OF THE STUDY

The aim of the study was to evaluate the perioperative outcomes of laparoscopic adrenalectomy in patients with adrenal tumors treated in a university center.

MATERIALS AND METHODS

We conducted a retrospective single-center study in the Departments of General Surgery of Sf. Spiridon County Clinical Emergency Hospital, Iași. The study included patients diagnosed with adrenal tumors and treated by laparoscopic adrenalectomy between 2020 and 2025. The aim of this phase was to evaluate the perioperative outcomes and histopathological profile of patients undergoing laparoscopic adrenalectomy in a university center.

The study included adult patients aged at least 18 years with adrenal tumors diagnosed by preoperative imaging who underwent laparoscopic adrenalectomy and had a final histopathological diagnosis available. Patients who underwent primary open surgery, those with known metastatic adrenal disease before surgery, patients with preoperatively documented invasion of adjacent structures, cases with incomplete clinical data, and those with severe comorbidities contraindicating surgical treatment were excluded from the analysis.

Data were retrospectively collected from medical records, operative reports, imaging documents, and histopathological reports. For each case, demographic and clinical characteristics were analyzed, including age, sex, body mass index, lesion laterality, and functional tumor status. Imaging tumor size, the main intraoperative and postoperative parameters, and the final histopathological diagnosis were also evaluated.

The perioperative parameters analyzed included operative time, estimated blood loss, need for conversion to open surgery, intraoperative and postoperative complications, need for intensive care unit admission, reintervention, length of hospital stay, and duration of postoperative drainage, when applicable. Regarding histopathological evaluation, tumor size on the surgical specimen, the final pathological diagnosis, and, in available cases, additional data provided by immunohistochemical examination were recorded.

Statistical analysis

Data were analyzed using descriptive and inferential statistical methods. Continuous variables were assessed for normality using the Shapiro-Wilk test and are presented as mean ± standard deviation or median and interquartile range (IQR), as appropriate. Categorical variables are reported as absolute frequencies and percentages. Comparisons between converted and non-converted procedures were performed using the Mann-Whitney U test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, as appropriate. Associations between continuous variables were evaluated using Spearman's rank correlation coefficient. All tests were two-sided, and a p-value <0.05 was considered statistically significant.

RESULTS

General characteristics of the study cohort

The retrospective cohort included 52 patients who underwent 53 procedures, as two patients had bilateral adrenal involvement; one underwent synchronous bilateral adrenalectomy, whereas the other underwent staged procedures. The mean age was 56.8 years, 35 patients (67.3%) were female, and the mean BMI was 27.0 kg/m². Lesions were right-sided in 28 patients (53.8%), left-sided in 22 (42.3%), and bilateral in 2 (3.8%).

Functional tumor status

Regarding functional tumor status, nonfunctioning tumors were the most frequent, identified in 26 patients (50.0%). Hypercortisolism was present in 14 patients (26.9%), whereas primary hyperaldosteronism and pheochromocytoma were each identified in 6 patients (11.5%).

Perioperative outcomes

Mean tumor size on preoperative imaging was 4.0 cm (median 3.7 cm). Mean operative time was 139.7 minutes (median 130; range 45-315). Estimated blood loss was available for 50 procedures, with a mean of 93.6 mL (median 70; range 20-350). Intraoperative complications occurred in 16/53 procedures (30.2%), and conversion to open surgery was required in 14/53 (26.4%).

Factors associated with conversion to open surgery

Conversion to open surgery was required in 14 of the 53 procedures (26.4%). Compared with procedures completed laparoscopically, converted procedures were performed in older patients (median age 65.0 *vs*. 54.0 years, p=0.045) and involved larger tumors on preoperative imaging (median 4.7 *vs*. 3.5 cm, p=0.050). Conversion was associated with a significantly longer operative time (180 *vs*. 120 min, p<0.001), greater estimated blood loss (200 *vs*. 50 mL, p<0.001), longer duration of peritoneal drainage (4 *vs*. 2 days, p<0.001), and prolonged hospital stay (13 *vs*. 11 days, p=0.013). BMI, sex, and tumor laterality were not significantly associated with conversion (tab. I).

Spearman correlation analysis showed a moderate positive correlation between operative time and estimated blood loss (ρ=0.539, p<0.001). Tumor size was positively correlated with estimated blood loss (ρ=0.378, p=0.016), whereas no significant correlation was observed between tumor size and operative time (ρ=0.183, p=0.240).

TABLE I.

Comparison of clinical and perioperative characteristics according to conversion to open surgery

Variable	Conversion (n=14)	No conversion (n=39)	p-value
Age, years	65.0 (60.2-71.5)	54.0 (48.5-64.5)	**0.045**
BMI, kg/m²	26.3 (22.4-33.4)	24.1 (22.1-31.8)	**0.600**
Imaging tumor size, cm*	4.7 (3.8-6.8)	3.5 (2.5-4.8)	**0.050**
Operative time, min	180 (168.8-207.5)	120 (105-132.5)	**<0.001**
Estimated blood loss, mL**	200 (150-250)	50 (50-80)	**<0.001**
Hospital stay, days	13 (10.2-15)	11 (8-12.5)	**0.013**
Drainage duration, days***	4 (4-5)	2 (2-3)	**<0.001**

Values are presented as median (IQR). * - Tumor size on preoperative imaging was available for 43 procedures; ** - estimated blood loss was available for 50 procedures; *** - drainage duration was available for 49 procedures.

Postoperative outcomes

Postoperative complications occurred in 5/53 procedures (9.4%), ICU admission was required in 2 (3.8%), and one patient required reintervention (1.9%). Median hospital stay was 11 days (range 5-31), and median drainage duration was 3 days (range 1-8). No 30-day mortality was recorded (tab. II).

TABLE II.

Postoperative outcomes of laparoscopic adrenalectomy

Variable	Value
Postoperative complications, n (%)	5/53 (9.4%)
Postoperative ICU admission, n (%)	2/53 (3.8%)
Reintervention, n (%)	1/53 (1.9%)
Hospital stay, median (range), days	11 (5-31)
Drainage duration, median (range), days	3 (1-8)
30-day mortality, n (%)	0/53 (0%)

Histopathological findings

Histopathological examination identified 35 adrenocortical adenomas (66.0%), 9 pheochromocytomas (17.0%), 6 cases of adrenal hyperplasia (11.3%), one cyst (1.9%), one myelolipoma (1.9%), and one carcinoma (1.9%) (fig. 1). Mean pathological tumor size was 4.07 cm (median 3.45; range 1.5-15.0 cm). Immunohistochemical examination was available in 15 cases.

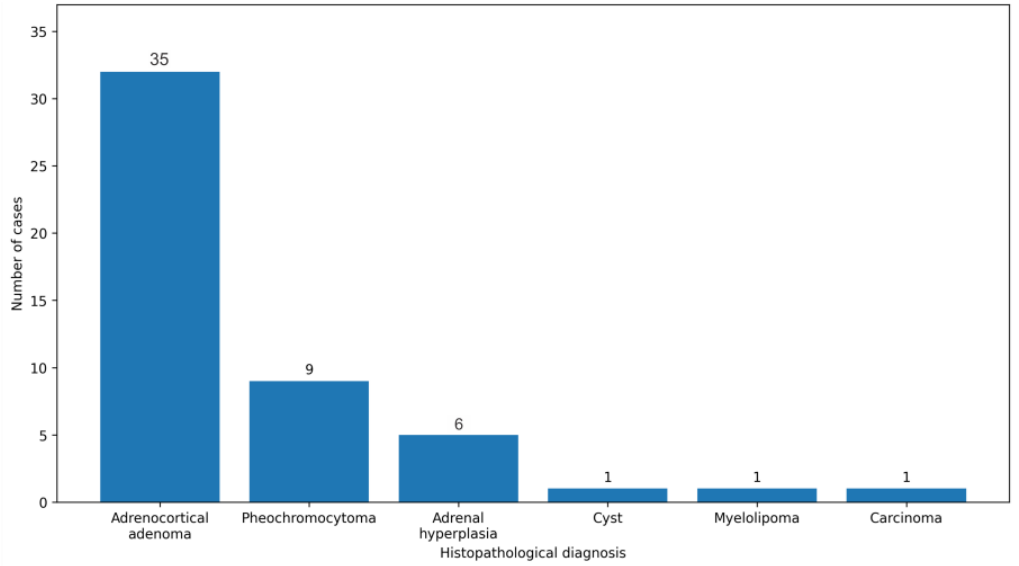

Fig. 1. Histopathological distribution of adrenal lesions.

DISCUSSION

The present study evaluated the perioperative outcomes of laparoscopic adrenalectomy in a single university center and identified several factors associated with conversion to open surgery. Overall, post-

operative outcomes were favorable, with a postoperative complication rate of 9.4%, a reintervention rate of 1.9%, and no 30-day mortality. However, conversion to open surgery was required in 26.4% of procedures, reflecting the presence of technically demanding cases within the analyzed cohort.

Converted procedures were associated with significantly longer operative time, greater estimated blood loss, prolonged drainage, and longer hospital stay. Patients requiring conversion were also older and had larger tumors on preoperative imaging, although the difference in tumor size was at the threshold of statistical significance. Previous large series have similarly identified tumor size as an important determinant of conversion. Shen *et al*. reported tumor size ≥5 cm as the strongest independent predictor of conversion, while a multicenter Spanish study identified tumor size >5 cm, obesity, and pheochromocytoma as independent risk factors. More recently, Hou *et al*., in a series of 911 patients, identified tumor diameter >7 cm, pheochromocytoma, malignant histology, and surgical approach as independent predictors of conversion (23-25).

The conversion rate observed in our cohort was higher than that reported in these larger series, in which conversion rates ranged from approximately 4% to 7% (23-25). This difference should be interpreted cautiously given the relatively small sample size of the present study and its retrospective single-center design. Importantly, conversion should not necessarily be regarded as a surgical failure, but rather as an appropriate intraoperative strategy when anatomical conditions, bleeding, adhesions, or tumor characteristics prevent safe laparoscopic completion. Previous studies have also demonstrated that conversion is associated with increased perioperative morbidity and prolonged hospitalization (23-25).

Correlation analysis further supported the relationship between operative complexity and blood loss. Operative time showed a moderate positive correlation with estimated blood loss ($\rho=0.539$, $p<0.001$), while tumor size was positively correlated with blood loss ($\rho=0.378$, $p=0.016$). However, tumor size was not significantly correlated with operative time in our cohort, suggesting that size alone may not fully reflect technical difficulty, which may also depend on tumor location, adhesions, vascular relationships, histological characteristics, and surgeon-related factors.

Despite the relatively high conversion rate, postoperative morbidity remained limited, with only two patients requiring postoperative intensive care and one requiring reintervention, while no 30-day mortality was recorded. Histopathological examination demonstrated a predominance of benign lesions, particularly adrenocortical adenomas and pheochromo-cytomas. Overall, our findings support laparoscopic adrenalectomy as a feasible approach for appropriately selected adrenal tumors while emphasizing the importance of preoperative risk assessment and readiness for conversion when safe laparoscopic completion cannot be achieved.

The present study has several limitations, including its retrospective single-center design and relatively small sample size, which may limit the generalizability of the findings. In addition, some perioperative variables were not available for all procedures, and the limited number of conversion events did not allow robust multivariable analysis. Therefore, the identified

associations should not be interpreted as independent predictors of conversion and require validation in larger prospective cohorts.

CONCLUSIONS

Laparoscopic adrenalectomy was a feasible and safe approach for selected adrenal tumors in our cohort, with a postoperative complication rate of 9.4%, a low reintervention rate, and no 30-day mortality.

Conversion to open surgery was associated with older age, longer operative time, greater estimated blood loss, prolonged drainage, and longer hospital stay, while BMI, sex, and tumor laterality were not significantly associated with conversion.

Operative time correlated positively with estimated blood loss, while larger tumor size was associated with increased blood loss. These findings emphasize the importance of appropriate patient selection, careful preoperative assessment, and readiness for conversion when safe laparoscopic completion cannot be achieved.

CONFLICT OF INTEREST AND FUNDING

The authors declare that there is no conflict of interest, and they received no specific funding regarding this scientific research.

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