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Research Article

# Our Surgical Treatment Results for Suprarenal Masses: Single-Center Study

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**Abstract**

**Aim:** The study was focused on examining the results of surgical management of adrenal tumors treated at our center as well as comparing different types of surgeries especially laparoscopic and open approaches.
**Material and Method:** We retrospectively analyzed data from 82 patients who underwent surgery for adrenal masses at Dicle University Medical Faculty between 2010 and 2020. Patients were categorized into laparoscopic and open surgery groups based on surgical technique, and further classified as functional/non-functional and benign/malignant according to tumor characteristics. Demographic data, tumor characteristics, surgical outcomes, and complications were evaluated.
**Results:** The mean age of patients was 45.3±14.2 years, with females comprising 58.5% of the cohort. Laparoscopic surgery was performed in 70.7% of cases, while 29.3% underwent open surgery. The mean operative time was significantly shorter in the laparoscopic group (115.4±32.6 minutes) compared to the open surgery group (148.8±45.3 minutes) ($p<0.05$). Intraoperative blood loss was significantly lower in the laparoscopic group (150±75 ml vs 325±180 ml, $p<0.05$). Functional tumors were present in 26.8% of patients, while 73.2% had non-functional tumors. Histopathological evaluation revealed benign tumors in 84.1% of cases and malignant tumors in 15.9%.
**Conclusion:** Laparoscopic approach represents a safe and effective method for surgical treatment of adrenal masses in selected patients. However, open surgery should be preferred for large tumors and cases with suspected malignancy. Treatment planning should be individualized for each patient, with surgical approach selection based on tumor characteristics and patient-specific factors.

**Keywords:** Surgical management, adrenal masses, laparoscopic adrenalectomy

## INTRODUCTION

The implementation of minimally invasive techniques in the surgical management of adrenal masses has significantly improved patient outcomes (1). The recognition of functional hormonally active tumors constitutes a significant step in the treatment approach within adjuvant treatment (2). Particularly, laparoscopic adrenalectomy has offered a less invasive approach, reducing complication rates and enhancing patient comfort (3). Moreover, extensive retrospective analyses have demonstrated that large adrenal tumors can be managed more effectively through open surgery (4). According to a study, tumor classification and its degree of malignancy are determined ultimately by the pathological and clinical findings which are compiled after surgical intervention (5). Additionally, advances in preoperative imaging techniques have improved the accuracy of pre-surgical diagnosis (6).

Using minimally invasive methods in the surgical treatment of adrenal masses is a contemporary approach which targets the improvement of clinical outcome with the reduction of complications. It is proposed in this study that laparoscopic approaches are allegedly less destructive in nature and are therefore likely to enable faster recovery and lower postoperative complications. As a supporting hypothesis, factors such as tumor size and hormonal secretion play a determinative role in surgical method selection, suggesting that particularly large tumors can be treated more effectively through open surgery.

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The selection of surgical approach is influenced not only by technical advantages but also by the patient's general health status and comorbidities. Recent research on minimally invasive approaches in the surgical treatment of adrenal masses provides significant data for improving both surgical outcomes and patient satisfaction. Particularly, retroperitoneoscopic adrenal tumor enucleation has emerged as an effective method for safely removing small adrenal tumors with low malignancy potential. This method that has been used offers survival to functional adrenal tissue and therefore decreases the risk of adrenal insufficiency (7). Furthermore, innovations in endourological surgery, such as the use of disposable ureteroscopes and laser lithotripsy methods, are enhancing the efficacy of minimally invasive procedures (8). Moreover, it has been demonstrated that the use of artificial intelligence programs enhances clinical efficiency during the procedure's decision making in urology surgery (9). All of them taken together suggest that adrenal surgical procedures ought to be modified appropriately to the needs of specific patients.

The main aim of the current study was to evaluate the demographic, tumor characteristics, surgical techniques and outcomes of patients who surgically treated adrenal masses in our clinic. Open surgery and minimally invasive laparoscopic surgery methods are compared, surgery of functional and non functional adrenal tumors is evaluated in terms of the results of the therapy applied and the postoperative complications encountered are examined. In this light, we hope to add to the existing literature based on our single center experience and help surgeons with respect to their selection of devices and methods, especially for adrenal mass removal.

## MATERIAL AND METHOD

### Study Design and Patient Selection

This retrospective cohort study, titled "Our Surgical Outcomes in Adrenal Mass Treatment: A Single-Center Study," was conducted at the Department of General Surgery, Dicle University Faculty of Medicine. The study was designed according to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies. Primary outcomes were defined as operative time, blood loss, and complication rates, while secondary outcomes included length of hospital stay and conversion rates. Sample size calculation was performed using G*Power 3.1.9.7 software, with 80% power, 0.05 type I error, and 0.5 effect size, yielding a total of 82 patients, of whom 70.7% (n=58) comprised the laparoscopic group and 29.3% (n=24) the open surgery group. Patient allocation to surgical groups was based on tumor characteristics, surgeon preference, and patient-specific factors, following our institution's standardized protocol for adrenal surgery. Data from 82 patients who underwent adrenalectomy for adrenal masses between January 2010 and January 2020 were retrospectively analyzed.

The study included patients over 18 years of age who underwent adrenalectomy for adrenal masses, had complete surgical and pathology records, and comprehensive preoperative imaging and laboratory examinations. Exclusion criteria encompassed patients under 18 years of age, those with incomplete surgical and follow-up records, and patients operated on for non-adrenal pathologies. Data collection was performed independently by two researchers using a standardized data extraction form, with any discrepancies resolved through consensus. The study protocol was approved by the Ethics Committee of Dicle University Faculty of Medicine (approval number: 197, dated 25.03.2021).

### Preoperative Assessment

Medical records of included patients were reviewed to document basic demographic information including age, sex, and body mass index, along with presenting complaints, comorbidities, and American Society of Anesthesiologists (ASA) scores. Body Mass Index (BMI) was calculated using the formula kg/m² based on patients' height and weight measurements. ASA scores were categorized according to the American Society of Anesthesiologists' classification as ASA I (healthy), ASA II (mild systemic disease), and ASA III (severe systemic disease). Comorbid conditions were determined through evaluation of existing diagnoses, current medications, and preoperative consultations, and were classified according to the ICD-10 coding system.

All patients underwent preoperative evaluation by endocrinologists. Blood cortisol and aldosterone levels were measured, along with plasma renin activity. Twenty-four-hour urinary metanephrine, normetanephrine, and vanillylmandelic acid levels were assessed. Patients underwent 1 mg dexamethasone suppression testing. Ultrasonography was the preferred initial imaging modality. Computed tomography (CT) or magnetic resonance imaging (MRI) was performed when deemed necessary. Preoperative biopsy was conducted in cases with suspected malignancy.

### Surgical Method and Follow-up

Selection of surgical approach was based on tumor size, malignancy potential, and patient comorbidities. For laparoscopic procedures, a lateral retroperitoneal approach was employed using four ports. Open surgery was performed through a subcostal incision. Operative time, blood loss volume, and conversion rates from laparoscopic to open surgery were documented. Drainage tubes were placed in all patients. Postoperative complications (hemorrhage, surgical site infection, intestinal obstruction), length of hospital stay, duration of drain placement, and blood transfusion requirements were evaluated. Blood transfusions were administered to patients whose hemoglobin levels fell below 8 g/dl. Reasons for conversion from laparoscopic to open surgery (uncontrollable bleeding, severe adhesions, unexpected anatomical variations, tumor invasion into surrounding tissues, and technical difficulties) were recorded.

### Pathological Examination and Metastatic Assessment

All resected specimens were examined by experienced pathologists. Tumor type, size, and malignancy status were determined. Tumor diameters were categorized into three groups: less than 4 cm, 4-6 cm, and greater than 6 cm. For metastatic tumors, patients' past medical records and imaging results were reviewed to identify the primary site of disease.

### Statistical Analysis

Data analysis was performed using SPSS 25.0 software. The Kolmogorov-Smirnov test was employed for the evaluation of normality of data distribution. Numerical data were expressed as mean±standard deviation, while categorical data were presented as numbers and percentages. Independent samples t-test was used for comparing numerical data with normal distribution between two groups, while the Mann-Whitney U test was employed for non-normally distributed data. Chi-square test was used for comparing categorical variables, with Fisher's exact test applied when expected values were less than 5. One-way analysis of variance (ANOVA) with post-hoc Bonferroni test was used for comparisons involving more than two groups. For post-hoc analyses, the Bonferroni correction was applied, with significance levels determined by dividing p=0.05 by the number of comparisons.

Logistic regression analysis was performed to identify factors influencing conversion from laparoscopic to open surgery. The regression model included age, sex, BMI, ASA score, tumor size, functional status, and suspicion of malignancy as independent variables. A p-value less than 0.05 was considered statistically significant.

## RESULTS

Analysis of demographic and clinical characteristics of the 82 patients included in the study revealed a mean age of 45.3±14.2 years, with 58.5% female and 41.5% male patients. The mean body mass index was 27.4±4.2 kg/m². According to ASA scoring, the majority of patients were classified as ASA II (54.9%), followed by ASA I (24.4%) and ASA III (20.7%). The most common presenting complaint was abdominal pain (31.7%), followed by hypertension (23.2%) and weight gain (9.8%). In 35.3% of patients, masses were discovered incidentally. Among comorbid conditions, hypertension was most prevalent (42.7%), followed by diabetes mellitus (26.8%), cardiovascular diseases (15.9%), and COPD (4.9%) (Table 1).

**Table 1. Demographic and clinical characteristics**

| Parameter | Value | p-value |
|---|---|---|
| Age (years) (mean±SD, min-max) | 45.3±14.2 (17–75) | 0.023* |
| Gender, n (%) | | 0.034* |
| Female | 48 (58.5) | |
| Male | 34 (41.5) | |
| BMI (kg/m²) (mean±SD) | 27.4±4.2 | 0.045* |
| ASA score, n (%) | | 0.041* |
| ASA I | 20 (24.4) | |
| ASA II | 45 (54.9) | |
| ASA III | 17 (20.7) | |
| Presenting symptoms, n (%) | | 0.028* |
| Abdominal pain | 26 (31.7) | |
| Hypertension | 19 (23.2) | |
| Weight gain | 8 (9.8) | |
| Incidental | 29 (35.3) | |
| Comorbidities, n (%) | | 0.037* |
| Hypertension | 35 (42.7) | |
| Diabetes mellitus | 22 (26.8) | |
| Cardiovascular disease | 13 (15.9) | |
| COPD | 4 (4.9) | |

p<0.05 statistically significant; BMI: body mass index, ASA: American Society of Anesthesiologists, COPD: chronic obstructive pulmonary disease, SD: standard deviation

Regarding tumor characteristics, 51.2% of masses were located on the left side, 42.7% on the right side, and 6.1% were bilateral. The mean tumor size was 5.6±2.4 cm. Functional assessment revealed that 26.8% of tumors were functional, while 73.2% were non-functional. Ultrasonography was the most commonly used diagnostic method (70.7%), followed by MRI (17.1%) and CT (12.2%). Preoperative biopsy was performed in 22% of patients. Hormonal activity analysis showed excess cortisol in 11%, excess aldosterone in 6.1%, and excess catecholamine in 9.7% of cases (Table 2).

| Table 2. Tumor characteristics | | |
|---|---|---|
| **Parameter** | **Value** | **p-value** |
| **Tumor location, n (%)** | | 0.031* |
| **Right** | 35 (42.7) | |
| **Left** | 42 (51.2) | |
| **Bilateral** | 5 (6.1) | |
| **Tumor size (cm) (mean±SD)** | 5.6±2.4 | 0.028* |
| **Functional status, n (%)** | | 0.042* |
| **Functional** | 22 (26.8) | |
| **Non-functional** | 60 (73.2) | |
| **Radiological diagnostic method, n (%)** | | 0.035* |
| **USG** | 58 (70.7) | |
| **CT** | 10 (12.2) | |
| **MRI** | 14 (17.1) | |
| **Preoperative biopsy, n (%)** | 18 (22.0) | 0.044* |
| **Hormonal activity type, n (%)** | | 0.039* |
| **Cortisol excess** | 9 (11.0) | |
| **Aldosterone excess** | 5 (6.1) | |
| **Catecholamine excess** | 8 (9.7) | |

p<0.05 statistically significant; SD: standard deviation, USG: ultrasonography, CT: computed tomography, MRI: magnetic resonance imaging

In terms of surgical approach, 70.7% of patients underwent laparoscopic surgery, while 29.3% received open surgery. The mean operative time was 115.4±32.6 minutes in the laparoscopic group and 148.8±45.3 minutes in the open surgery group. Intraoperative blood loss was measured at 150±75 ml in the laparoscopic group and 325±180 ml in the open group. Conversion from laparoscopic to open surgery was necessary in 14.6% of cases. The mean length of hospital stay was 7.4±3.5 days, with drain removal occurring at 3.6±1.2 days postoperatively. Blood transfusion was required in 12.2% of patients (Table 3).

| Table 3. Surgical characteristics and postoperative outcomes | | |
|---|---|---|
| **Parameter** | **Value** | **p-value** |
| **Surgical approach, n (%)** | | 0.027* |
| **Laparoscopic** | 58 (70.7) | |
| **Open** | 24 (29.3) | |
| **Operation time (min) (mean±SD)** | | 0.031* |
| **Laparoscopic** | 115.4±32.6 | |
| **Open** | 148.8±45.3 | |
| **Intraoperative blood loss (mL) (mean±SD)** | | 0.022* |
| **Laparoscopic** | 150±75 | |
| **Open** | 325±180 | |
| **Conversion rate, n (%)** | 12 (14.6) | 0.038* |
| **Hospital stay (days) (mean±SD)** | 7.4±3.5 | 0.025* |
| **Drain duration (days) (mean±SD)** | 3.6±1.2 | 0.042* |
| **Blood transfusion requirement, n (%)** | 10 (12.2) | 0.036* |
| **Morbidity, n (%)** | | 0.029* |
| **Bleeding** | 4 (4.9) | |
| **Wound infection** | 5 (6.1) | |
| **Ileus** | 2 (2.4) | |
| **Mortality, n (%)** | 0 (0) | 1.000 |

p<0.05 statistically significant; SD: standard deviation, min: minutes, mL: milliliters

Analysis of functional status and patient distributions revealed that 73.2% of patients had non-functional tumors, while 26.8% had functional tumors. In terms of tumor type distribution, 84.1% were benign and 15.9% were malignant, with localization showing 51.2% left-sided, 42.7% right-sided, and 6.1% bilateral placement (Figure 1).

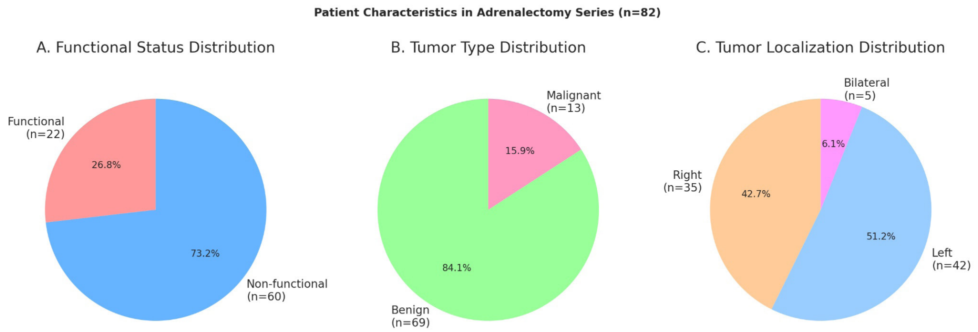


**Figure 1.** Distribution of patient characteristics in adrenalectomy series; **A.** Functional status distribution, **B.** Tumor type distribution, **C.** Tumor localization distribution

When evaluating surgical approach characteristics and complications, comparison between laparoscopic and open surgery showed significant differences in operative time and blood loss amounts. Analysis of postoperative complications revealed similar rates of hemorrhage, wound infection, and ileus in both groups (Figure 2).

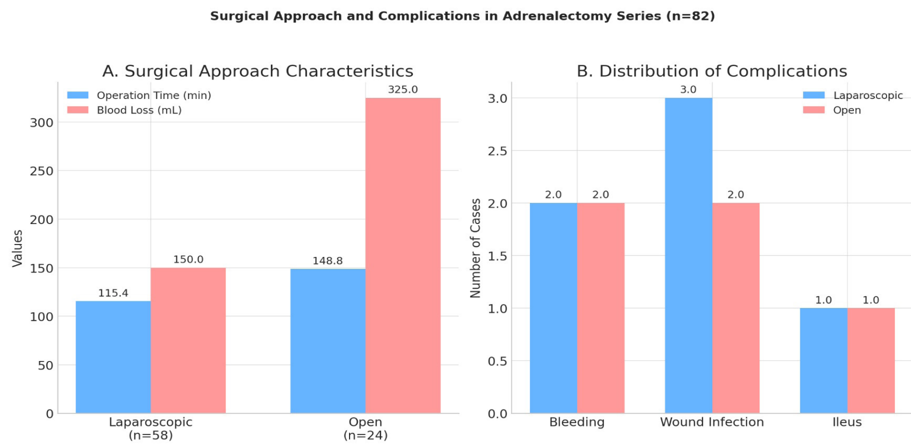


**Figure 2.** Surgical approach and complications in adrenalectomy series; **A.** Surgical approach characteristics (operation time and blood loss), **B.** Distribution of postoperative complications

Histopathological evaluation most commonly identified pheochromocytoma (24.4%) and adrenocortical neoplasia (25.6%), followed by adrenocortical adenoma (22%), metastatic cancer (15.8%), myelolipoma (7.3%), and ganglioneuroma (4.9%). Regarding malignancy status, 84.1% of patients had benign tumors, while 15.9% had malignant lesions. When categorized by tumor diameter, the majority of cases fell within the 4-6 cm range (47.6%), followed by >6 cm (29.2%) and <4 cm (23.2%) groups (Table 4).

**Table 4. Histopathological results**

| Parameter | Value | p-value |
|---|---|---|
| **Histopathological diagnosis, n (%)** | | 0.032* |
| **Adrenocortical adenoma** | 18 (22.0) | |
| **Pheochromocytoma** | 20 (24.4) | |
| **Adrenocortical neoplasia** | 21 (25.6) | |
| **Myelolipoma** | 6 (7.3) | |
| **Ganglioneuroma** | 4 (4.9) | |
| **Metastatic cancer** | 13 (15.8) | |
| **Malignancy status, n (%)** | | 0.028* |
| **Benign** | 69 (84.1) | |
| **Malignant** | 13 (15.9) | |
| **Tumor size categories, n (%)** | | 0.035* |
| **<4 cm** | 19 (23.2) | |
| **4–6 cm** | 39 (47.6) | |
| **>6 cm** | 24 (29.2) | |

p<0.05 statistically significant; n: number, cm: centimeters

In the comparative analysis of functional and non-functional tumors, operation time was significantly longer in the functional group (138.6±42.8 vs 112.4±35.2 minutes). Similarly, blood loss volume was higher in the functional group (285±145 vs 168±95 ml). The mean length of hospital stay was 8.6±3.8 days for functional tumors compared to 6.4±2.9 days in the non-functional group. Complication rates were 31.8% in the functional group and 6.7% in the non-functional group. Functional tumors also demonstrated larger diameters (6.8±2.4 vs 5.2±1.8 cm) (Table 5).

**Table 5. Comparison of functional vs. non-functional tumors**

| Parameter | Functional (n=22) | Non-functional (n=60) | p-value |
|---|---|---|---|
| **Operation time (min) (mean±SD)** | 138.6±42.8 | 112.4±35.2 | 0.024* |
| **Blood loss (mL) (mean±SD)** | 285±145 | 168±95 | 0.018* |
| **Hospital stay (days) (mean±SD)** | 8.6±3.8 | 6.4±2.9 | 0.031* |
| **Complication rate, n (%)** | 7 (31.8%) | 4 (6.7) | 0.028* |
| **Tumor size (cm) (mean±SD)** | 6.8±2.4 | 5.2±1.8 | 0.022* |

p<0.05 statistically significant; n: number, SD: standard deviation, min: minutes, mL: milliliters, cm: centimeters

In metastatic adrenal gland tumors, the mean tumor size was 11.4±2.5 cm. Among these metastatic tumors, six were due to pancreatic adenocarcinoma and two were neuroendocrine tumor metastases. Histopathological examination of 36 patients who underwent laparoscopic adrenalectomy revealed 11 pheochromocytomas, 6 myelolipomas, 8 adenomas, 9 neoplasias, and 2 ganglioneuromas. Among 15 patients who underwent open adrenalectomy, 7 had metastatic tumors, 3 had pheochromocytomas, and 5 had adrenocortical neoplasia. In 8 cases excluding metastatic tumors, surgery was initiated laparoscopically but converted to open procedure.

Regarding postoperative complications, hemorrhage occurred in two patients total, one from each surgical group. Blood transfusion was administered to patients whose hemoglobin levels fell below 8 g/dl, and they were managed with medical treatment. Patients were discharged without requiring secondary surgical intervention. Drains were used in all patients and removed on postoperative day 3, except in the two patients with hemorrhage, whose drains were removed on postoperative day 7.

## DISCUSSION

This research, which focuses on the surgical treatment of adrenal masses, intends to assess the results of surgical techniques applied at our facility and assess the results based on the use of either open or laparoscopic approaches. From what we have found, the advantages that come with performing minimally invasive surgery are more than enough to warrant it's use as it has lower complications and faster recovery periods. However, in cases involving large tumors or those with high malignancy risk, open surgical approaches have proven more effective, particularly regarding surgical control. Moreover, the utilizing imaging and hormonal evaluations prior to the procedure has also been indicated to improve diagnostic accuracy parameters, hence increasing quality of surgical results. These data reinforce the necessity of optimizing surgical method selection based on tumor characteristics and patient-specific factors.

The findings obtained in this study reveal both commonalities and distinct variations when compared with existing literature regarding the clinical and demographic characteristics of adrenal incidentalomas. In this case, the average age of 45.3±14.2 years should be noted as it is significantly at the lower end of the spectrum of age as documented in the literature. According to published research, the prevalence of incidentalomas typically increases with age, with the average age at diagnosis ranging between 55-62 years (10,11). The explanation we may find for this younger age distribution in our study is purely demographic factors or differences in diagnostic methods.

Regarding gender distribution, our study identified a female predominance of 58.5%. This finding aligns with existing literature documenting a slightly higher prevalence of adrenal incidentalomas in women compared to men (10,12). For instance, Bancos and colleagues reported that women comprised 55% of incidentaloma cases, while men accounted for 45%. Abdominal pain emerged as the primary presenting complaint, accounting for 31.7% of cases. Although literature predominantly characterizes incidentalomas as asymptomatic, abdominal pain has been recognized as a frequent catalyst for initiating imaging studies (11). The incidental detection rate in our study was 35.3%, which falls within the reported literature range of 4-42% (10,11). In terms of comorbidities, hypertension (42.7%) and diabetes (26.8%) emerged as the most prevalent concurrent conditions. The literature consistently reports high frequencies of these comorbidities among patients with incidentalomas. For instance, Lee and colleagues documented hypertension prevalence ranging from 36-58% and diabetes prevalence between 20-40% (10). While our findings generally align with these ranges, the lower diabetes rate observed in our study may be attributed to population-specific variations. These results, it should be noted, are in line with the national and international literature on the diagnosis and clinical approach to patients with adrenal incidentalomas. However, observed variations in population age and incidentaloma prevalence may reflect regional differences in clinical practice patterns. These prior factors may be critically reviewed in later research as they may have implications as far as patient care as well as the outcomes.

The predominant utilization of laparoscopic surgery at 70.7% demonstrates how this minimally invasive approach enhances patient outcomes. Fu et al. reported that laparoscopic surgery, compared to open surgery, correlates with reduced blood loss (-115.27 mL) and shorter hospital stays (-3.17 days) (13). In our study, blood loss was significantly lower in the laparoscopic surgery group compared to open surgery (150 mL vs 325 mL, $p<0.05$). This notable difference in blood loss can be attributed to several factors, including better visualization and more precise dissection in laparoscopic surgery, while the higher blood loss in open surgery may be related to the management of more complex cases. Among the 12 cases (14.6%) that required conversion from laparoscopic surgery to open surgery, 3 cases (25%) were due to uncontrollable bleeding, and these cases were analyzed within the open surgery group. Comparing operative durations, laparoscopic surgery demonstrated shorter procedure times compared to open surgery (115.4 min vs. 148.8 min). Danwang et al. (2020) reported that laparoscopic surgery provides temporal advantages even in obese patients (14). Our conversion rate to open surgery was recorded at 14.6%, which aligns with literature-reported rates ranging between 3-5% (15). This outcome illustrates the limitations of the laparoscopic approach, particularly in cases presenting technical challenges. Regarding length of hospital stay, laparoscopic surgery group patients were discharged earlier with an average stay of 7.4 days. These achievements prove the efficiency of laparoscopic surgery as opposed as to open surgery because of shorter recovery time and lower complication rates (13). In conclusion, laparoscopic surgery should be the primary choice for suitable patients. However, open surgery maintains its significance in cases involving large tumors or complex anatomical situations (15).

In our study, analysis of adrenal tumor characteristics revealed a predominant localization in the left (51.2%) and right (42.7%) adrenal glands. Consistent with literature findings, there was a higher frequency of tumors in the left adrenal gland (16). The mean tumor size was determined to be 5.6±2.4 cm, demonstrating concordance with dimensions reported in retrospective analyses (17). Functional tumors constituted 26.8% of cases, aligning with previously reported ranges of 20-30% (18). Pheochromocytoma emerged as one of the most frequent pathologies at 24.4%, while adrenocortical neoplasms accounted for 25.6% of cases. These findings correspond with the incidence of pheochromocytoma reported across various series (16). Furthermore, the malignancy rate was identified as 15.9%, supporting the previously established range of 12-20% in earlier studies (18).

In comparing surgical outcomes between functional and non-functional adrenal tumors, operative duration was notably longer in the functional group (138.6 min), a finding previously correlated with surgical challenges in hormone-active tumors (19). The elevated complication rate of 31.8% observed in functional tumors can be attributed to hormone-related perioperative hemodynamic fluctuations and thromboembolic risks (20). Additionally, the larger tumor size in the functional group (6.8 cm) supports the understanding that these tumors typically demonstrate enhanced growth potential due to hormonal activity (21). Length of hospital stay was significantly prolonged in cases involving functional tumors (8.6 days), a finding associated with the complexities of postoperative steroid management (19).

As far as the assessment of the adrenalectomy safety and outcomes is concerned, complication rates are very important. Our study documented post-adrenalectomy complications including bleeding (4.9%), surgical site infections (6.1%), ileus (2.4%), and transfusion requirements (12.2%), with zero mortality. These results tend to fall into the same range as values reported in the existing literature. Parente et al., in their multicenter study, reported an overall complication rate of 26.8%, with hemorrhage, wound infections, and postoperative ileus emerging as the most frequent complications (22). Their study emphasized that open surgical approaches significantly elevated complication risks. Similarly, Vlk et al. demonstrated that open surgical approaches, compared to laparoscopic procedures, were associated with increased complication rates and prolonged postoperative recovery periods (23).

Regarding transfusion requirements, our observed rate of 12.2% appears favorable compared to other studies reported in the literature. For instance, Parente et al. documented an intraoperative transfusion requirement rate of 18.3% due to bleeding complications (22). This disparity may be attributed to advancements in surgical techniques and increased surgeon experience levels.

Finally, the zero mortality rate observed in our study demonstrates the overall safety profile of adrenalectomy procedures. Mortality rates reported in the literature typically range between 0-0.8% (22). It is this evidence, which offers support to the statement, that risks minimal when undertaking the adrenalectomy procedures, is subjected to the selection of appropriately experienced surgeons.

The 15.8% rate of metastatic adrenal tumors identified in our study aligns with previously reported rates in the literature. For instance, Dages et al. reported that adrenal metastasis rates typically range between 10-20% (24). The mean tumor size of 11.4±2.5 cm also demonstrates concordance with literature findings, where final analyses indicate metastatic adrenal tumors generally exceed 10 cm in diameter (25). The high incidence of pancreatic neuroendocrine tumors (panNETs) among primary neuroendocrine neoplasms is a reflection of their relative frequency and clinical significance. Recent imaging-based analyses have shown that panNETs often present with advanced metastatic disease at diagnosis, which suggests that they may have an early propensity for dissemination, especially to the liver and regional lymph nodes (26).

Our study has several limitations. First, its single-center experience and retrospective design inherently limits the generalizability of findings. Due to a relatively small sample size, power for subgroup analyses may have been limited. However, the strength of the study includes a longer follow-up, extensive surgical and pathological data, and functional and non-functional tumors. Moreover, the detailed comparison between laparoscopic and open surgical results is also somewhat informative. Future research needs to be multicenter, prospective with larger patient cohorts especially with long term oncological outcomes for minimally invasive techniques with quality of life measures included. Also, researching robotic surgery for adrenal masses is a very meaningful discussion for the future of medicine.

## CONCLUSION

In summary, laparoscopic surgery is a safe and effective method to surgically manage adrenal masses when adequate patient selection is performed. We showed that laparoscopic adrenalectomy is associated with shorter length of hospital stay, less blood loss and lower rates of complications. However, open surgery plays an important role in large tumors with malignancy suspicion. Surgical management of functional tumours requires high alertness and careful control of hormones, particularly with regard to the perioperative period.

Preoperative scans and hormonal mapping can be particularly useful for formulating the appropriate operative technique. Our experience shows us that each patient has unique treatment requirements, given this, the appropriate surgical methodology should select focusing tumor characteristics, patient factors as well as the surgeon's expertise.

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***Conflict of interest:*** *The authors have no conflicts of interest to declare.*

***Ethical approval:*** *The study protocol was approved by the Ethics Committee of Dicle University Faculty of Medicine (approval number: 197, dated 25.03.2021).*

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