*Osmangazi Journal of Med, 2025;47(2):176-185*
*DOI: 10.20515/otd.1594919*

*Research Article*
*Araştırma Makalesi*

**Osmangazi Journal of Medicine**
**e-ISSN: 2587-1579**

# The Effect of Hormone Activity and Malignancy on Surgical Parameters in Laparoscopic Adrenalectomy

Laparoskopik Adrenalektomide Hormon Aktivitesi ve Malignitenin Cerrahi Parametrelere Etkisi

[1]Osman Gerçek, [2]Emre Ballı, [1]Murat Cengizhan Atik,[1]Veli Mert Yazar, [1]Kutay Topal, [1]Haşmet Sarıcı

[1]Afyonkarahisar Sağlık Bilimleri Üniversitesi Tıp Fakültesi, Üroloji Anabilim Dalı, Afyonkarahisar, Türkiye
[2]Afyonkarahisar Sağlık Bilimleri Üniversitesi Tıp Fakültesi, Genel Cerrahi Anabilim Dalı, Afyonkarahisar, Türkiye

***ORCID ID of the authors***
OG. 0000-0002-8710-7171
EB. 0000-0002-3201-9756
MCA. 0009-0001-6698-6007
VMY. 0000-0001-7885-1401
KT. 0000-0001-7501-7251
HS. 0000-0002-1303-3931

**Correspondence / Sorumlu yazar:**
Osman GERÇEK

Afyonkarahisar Sağlık Bilimleri Üniversitesi Tıp Fakültesi, Üroloji Anabilim Dalı, Afyonkaraqhisar, Türkiye

**e-mail:** osmangercek1989@hotmail.com

**Abstract:** Tumours of the adrenal gland can be encountered in various forms ranging from non-hormone-secreting benign adenomas to hormone-secreting malignant adrenocortical carcinomas. This study aimed to investigate the effect of hormone-functional tumours, malignant pathological results and tumour size on surgical and clinical parameters in patients undergoing laparoscopic transperitoneal adrenalectomy. A total of 63 patients who underwent transperitoneal laparoscopic adrenalectomy were included in this study. In the first stage of the study, two groups were formed as hormone-functional adrenal tumours and hormone-non-functional adrenal tumours. In the second stage of the study, the patients were histopathologically divided into 2 groups as malignant and benign adrenal tumours. The effects of hormone activity and malignancy on surgical parameters were investigated in both stages. Mean duration of operation and intraoperative blood loss were higher in the group with malignant pathology (p=0.041, p=0.014, respectively). The duration of operation was shorter in Conn's syndrome compared to the Cushing's syndrome and pheochromocytoma groups (p=0.038). There was a moderate positive correlation between pathological tumour size and duration of operation, which was statistically significant (r=0.449, p<0.001). The success of laparoscopic adrenalectomy is affected by the morphological and functional characteristics of the mass. Prolonged operation times and increased bleeding have been observed in malignant masses. It is esential for surgeons performing the operation to be aware that they may encounter varying clinical presentations both during and after the procedure, depending on the morphological and functional characteristics of the mass.
**Keywords:** Laparoscopy, Adrenalectomy, Adrenocortical Carcinoma, Cushing's Syndrome

**Özet:** Adrenal bezdeki tümörlerle, hormon salgılamayan benign adenomlardan, hormon salgılayan malign adrenokortikal karsinomlara kadar değişen şekillerde karşılaşılabilir. Bu çalışmada; hormon fonksiyonel olan tümörlerin, malign patolojik sonuçların ve tümör büyüklüğünün laparoskopik transperitoneal adrenalektomi uygulanan hastalarda, cerrahi ve klinik parametrelere etkisinin araştırılması amaçlanmıştır. Çalışmamıza transperitoneal laparoskopik adrenalektomi operasyonu gerçekleştirilen 63 hasta dahil edildi. Çalışmanın ilk aşamasında, hormon fonksiyonel ve hormon fonksiyonel olmayan adrenal tümörler olarak 2 grup oluşturuldu. Çalışmanın ikinci aşamasında ise histopatolojik olarak malign ve benign adrenal tümörler olarak 2 gruba ayrıldı. Her iki aşamada da hormon aktivitesinin ve malignensinin cerrahi parametrelere etkisi araştırıldı. Ortalama operasyon süresi ve intraoperatif ortalama kan kaybı malign patolojiye sahip grupta daha yüksek izlendi (sırasıyla; p=0.041, p=0.014). Conn sendromunda operasyon süresinin Cushing ve feokromositoma grubuna göre daha kısa olduğu izlendi (p=0.038). Patolojik tümör boyutu ile operasyon süresi arasında orta düzeyde pozitif bir korelasyon olduğu izlendi ve istatistiksel olarak anlamlıydı (r=0.449, p<0.001). Laparoskopik adrenalektomi operasyonunun başarısı kitlenin morfolojik ve fonksiyonel özelliklerinden etkilenmektedir. Malign kitlelerde uzamış operasyon süreleri ve artmış kanama miktarı olduğu gösterilmiştir. Operasyonu gerçekleştirecek cerrahların, kitlenin morfolojik ve fonksiyonel farklılıklarına bağlı olarak operasyon sırasında ve sonrasında farklı klinik tablolarla karşılaşabileceklerini bilmeleri önemli görünmektedir.
**Anahtar Kelimeler:** Laparoskopi, Adrenalektomi, Adrenokortikal Karsinom, Cushing Sendromu

**Ethics Committee Approval:** The study was approved by Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (2011-KAEK-2) (Decision No: 2024/7, Date: 19.04.2024)

**Informed Consent:** This study did not require informed consent.

**Authorship Contributions:** Surgical and Medical Practices: OG, EB, VMY. Concept: OG, MCA, VMY, HS. Design: OG, MCA, KT, HS. Data Collection or Processing: EB, MCA, VMY, KT, HS. Analysis or Interpretation: OG, MCA, VMY, KT, HS. Literature Search: OG, EB, VMY. Writing: OG, KT.

**Copyright Transfer Form:** Copyright Transfer Formwas signed by all authors.

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study received no financial support.

**Received** : 02.12.2024

**Accepted** : 15.01.2025

**Published** : 24.01.2025

**How to cite/ Atıf için:** Gerçek O, Ballı E, Atik MC, Yazar VM, Topal K, Haşmet Sarıcı, The Effect of Hormone Activity and Malignancy on Surgical Parameters in Laparoscopic Adrenalectomy; Osmangazi Journal of Medicine, 2025;47(2):176-185

## 1. Introduction

Thornton JK performed the first adrenalectomy operation recorded in the literature in 1889 (1). In 1992, Gagner et al. described transabdominal laparoscopic adrenalectomy, marking a turning point in surgical practice (2). As a minimally invasive and effective treatment, laparoscopic adrenalectomy has been widely accepted and has become the standard treatment for most adrenal tumours. At present, the transperitoneal approach is the most commonly used method for laparoscopic adrenalectomy (3, 4). Compared to open surgery, laparoscopic adrenalectomy provides numerous benefits, such as reduced intraoperative blood loss, shorter hospital stays, decreased postoperative pain, and quicker recovery times (3, 5).

Tumours in the adrenal gland have very different clinical and pathological presentations. They may be encountered ranging from benign adenomas, which do not secrete hormones to malignant adrenocortical carcinomas, which do secrete hormones (6-8). The main indications for adrenalectomy are functional adrenal tumours and suspicion of malignancy (9).

This study aimed to investigate the effects of hormonally functional tumours, malignant pathological results, and tumour size on surgical parameters and hospital stay in patients undergoing laparoscopic transperitoneal adrenalectomy.

## 2. Materials and Methods

### 2.1. Patient's selection

This study was conducted in the Urology and General Surgery Clinic of the Afyonkarahisar University Hospital. The data was recorded retrospectively after the ethical approval (Clinical Research Ethics Committee of Afyonkarahisar University, 2011-KAEK-2, 2024/7). Our study was conducted in accordance with the principles of the Declaration of Helsinki.

A total of 73 patients who underwent transperitoneal laparoscopic adrenalectomy between November 2019 and November 2023 at the Department of Urology and General Surgery, Faculty of Medicine, Afyonkarahisar were included in this study.

Patients aged between 18 and 90 years with unilateral adrenal masses who underwent transabdominal laparoscopic adrenalectomy were included in the study. Exclusion criteria comprised bilateral adrenalectomy, open surgery or conversion to open surgery, retroperitoneal laparoscopic approach, radiological or pathological tumour size over 100 cc, bleeding disorder, operation performed without discontinuation antiplatelet therapy, and adrenalectomy performed simultaneously with nephrectomy.

Three patients who initially underwent laparoscopic surgery but were converted to open surgery for various reasons, and one patient who underwent bilateral adrenalectomy, were excluded from the study. The reasons for conversion to open surgery were abnormal intraoperative bleeding in two patients and the inability to perform dissection due to excessive adhesion to surrounding tissues in one patient. Additionally, six patients with radiological and pathological mass volumes exceeding 100 cc were excluded to ensure homogeneity of the study. Of the six patients who were larger than 100 cc and were not included in the study, three had pheochromocytoma and the other three had adrenocortical tumour. Radiological and pathological tumour volumes were calculated using the formula ($V=\pi/6$)*length*width*height). Consequently, the study proceeded with a total of 63 patients.

### 2.2. Pre-operative preparation and surgical technique

The main indications for adrenalectomy were tumours causing hormone secretion and related symptoms or suspected malignancy. All patients underwent a preoperative endocrinological evaluation to investigate the functional structure of the tumour and CT scanning, which is the gold standard imaging method in adrenal gland pathologies. Appropriate medical treatment was started preoperatively in hormone-active patients. All operations were performed by surgeons with similar experience and using the same transperitoneal surgical technique. Experienced uropathologists evaluated pathology preparations.

### 2.3. Data collection

Age, gender, comorbidities, presenting symptoms, side, size, hormone activity and subtype of the tumour were recorded preoperatively. Duration of operation, mean amount of bleeding, development of complications, and length of hospital stay were analysed. The histopathological type and pathological size of the tumour were also examined by pathology reports.

### 2.4. Study design

In the first stage of the study, two groups were formed as hormone-functional adrenal tumours and hormone-non-functional adrenal tumours. In the second stage of the study, the patients were histopathologically divided into 2 groups as malignant and benign adrenal tumours. The effects of hormone activity and malignancy on surgical parameters were investigated in both stages. Furthermore, the effects of subtypes of functional adrenal masses on surgical parameters were compared among themselves. The relationship between radiological and pathological tumour size and surgical parameters was examined.

### 2.5. Statistical Analysis

Statistical analysis of the study data was performed with the IBM SPSS (Statistical Package for the Social Sciences) version 20.0 program. The Kolmogorov-Smirnov (K-S) test was used to assess if the variables had a normal distribution. For comparing paired groups, the Student's T-test was used for normally distributed variables, while the Mann-Whitney U test was used for parameters that did not have a normal distribution. Multivariate cross-tabulations were assessed using either the Chi-square test or the Fisher Exact test. Kruskal-Wallis and ANOVA tests were used for comparisons with more than two groups. The Spearman correlation test or Pearson correlation test was used to analyse the correlation between different parameters. The independent effects of different predictors on operative time and bleeding volume were examined separately using a multiple linear regression model. Model fit was examined using required residual and fit statistics. The results were considered statistically significant when $p<0.05$.

### 2.6. Tables

**Table 1.** Comparison of demographic and clinical data of patients according to hormone activity

| | **Functional N=30 n %** | **Non-Functional N=33 n %** | **p** |
|---|---|---|---|
| **Age** | 55.43±11.20 | 57.15±13.82 | 0.248 |
| **Gender** | | | |
| Male | 7 (23.3) | 15 (45.5) | 0.111 |
| Female | 23 (76.7) | 18 (54.5) | |
| **Side** | | | |
| Right | 12 (40) | 21 (63.6) | 0.079 |
| Left | 18 (60) | 12 (36.4) | |
| **Identification** | | | |
| Incidental | 14 (46.7) | 25 (75.8) | **0.022** |
| Symptomatic | 16 (53.2) | 8 (24.2) | |
| **DM** | | | |
| Yes | 17 (56.7) | 10 (30.3) | **0.044** |
| No | 13 (43.3) | 23 (69.7) | |
| **HT** | | | |
| Yes | 24 (80) | 17 (51.5) | **0.033** |
| No | 6 (20) | 16 (48.5) | |
| **Complications** | | | |
| Yes | 2 (6.7) | 1 (3) | 0.601 |
| No | 28 (93.3) | 32 (97) | |
| **Duration of Operation (min)** | 63.67±15.97 | 71.06±18.53 | 0.127 |
| **Duration of Hospital Stay (days)** | 4.03±1.24 | 3.61±1.69 | **0.021** |
| **Intraoperative Bleeding (ml)** | 55.98±25.37 | 66.48±26.53 | 0.074 |
| **Radiological Tumour Volume (cc)** | 7.15 (3.94-18.66)* | 18.4 (13.80-32.65)* | **<0.001** |
| **Pathological Tumour Volume (cc)** | 6.25 (3.30-16.29)* | 12.8 (8.22-21.20)* | **0.012** |

*(*: median (25th-75th percentile), DM: Diabetes Mellitus, HT: Hypertension)*

**Table 2.** Comparison of demographic and clinical data of patients according to pathological results

| | **Benign N=42 n %** | **Malignant N=21 n %** | **p** |
|---|---|---|---|
| **Age** | 54.93±12.68 | 56.29±12.95 | 0.692 |
| **Gender** | | | |
| Male | 13 (31) | 9 (42.9) | 0.350 |
| Female | 29 (69) | 12 (57.1) | |
| **Side** | | | |
| Right | 21 (50) | 12 (57.1) | 0.789 |
| Left | 21 (50) | 9 (42.9) | |
| **Identification** | | | |
| Incidental | 25 (59.5) | 14 (66.7) | 0.784 |
| Symptomatic | 17 (40.5) | 7 (33.3) | |
| **DM** | | | |
| Yes | 19 (45.2) | 7 (33.3) | 0.424 |
| No | 23 (54.8) | 14 (66.7) | |
| **HT** | | | |
| Yes | 32 (76.2) | 9 (42.9) | **0.009** |
| No | 10 (23.8) | 12 (57.1) | |
| **Complications** | | | |
| Yes | 3 (7.1) | 0 (0) | 0.545 |
| No | 39 (92.9) | 21 (100) | |
| **Duration of Operation (min)** | 64.17±16.63 | 74.29±17.97 | **0.041** |
| **Duration of Hospital Stay (days)** | 3.69±1.29 | 4.05±1.85 | 0.627 |
| **Intraoperative Bleeding (ml)** | 55.54±24.20 | 73.36±26.90 | **0.014** |
| **Radiological Tumour Volume (cc)** | 10 (5.88-21.07)* | 20.95 (13.8-47.15)* | **0.005** |
| **Pathological Tumour Volume (cc)** | 7.9 (4.14-16.29)* | 15.95 (8.38-25.05)* | **0.007** |

*(*: median (25th-75th percentile), DM: Diabetes Mellitus, HT: Hypertension)*

**Table 3.** Comparison of Clinical Data According to Subtypes of Functional Adrenal Tumours

| | **Pheochromocytoma N=10 n %** | **Cushing N=12 n %** | **Conn N=8 n %** | **p** |
|---|---|---|---|---|
| **Duration of Operation (min)** | 68.50±15.28 | 67.50±15.30 | 51.88±13.07 | **0.038**[k] |
| **Duration of Hospital Stay (days)** | 4.40±1.77 | 4.08±0.79 | 3.50±0.92 | 0.395[k] |
| **Intraoperative Bleeding (ml)** | 52.55±22.84 | 63.13±28.72 | 49.56±23.40 | 0.474[k] |
| **Radiological Tumour Volume (cc)** | 19.60 (7.07-39.97)* | 7.70 (5.60-12.69)* | 2.54 (2.16-6.23)* | **0.004**[k1] |
| **Pathological Tumour Volume (cc)** | 18.81 (5.67-34.27)* | 6.66 (4.62-14.28)* | 2.58 (1.51-5.11)* | **0.007**[k2] |

*([k]:Kruskal-Wallis Test, [k1]: Pheochromocytoma-Conn; p=0.001 (Benforrini Correction p=0.017), [k2]: Pheochromocytoma-Conn; p=0.004 (Benforrini Correction p=0.017), *:median (25th-75th percentile))*

**Table 4.** Correlation analysis of demographic and clinical data

| | | **Age** | **Duration of Operation (min)** | **Amount of Bleeding (ml)** | **Duration of Hospital Stay (days)** | **Radiological Tumour Volume (cc)** | **Pathological Tumour Volume (cc)** |
|---|---|---|---|---|---|---|---|
| **Age** | r | | | | | | |
| | p | | | | | | |
| **Duration of Operation (min)** | r | -0.116 | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | p | 0.364 | | | | |
| **Amount of Bleeding (ml)** | r | 0.259 | 0.251 | | | |
| | p | **0.040** | **0.047** | | | |
| **Duration of Hospital Stay (days)** | r | 0.177 | -0.111 | -0.017 | | |
| | p | 0.166 | 0.385 | 0.894 | | |
| **Radiological Tumour Volume (cc)** | r | -0.008 | 0.331 | 0.001 | -0.124 | |
| | p | 0.949 | **0.008** | 0.997 | 0.333 | |
| **Pathological Tumour Volume (cc)** | r | -0.033 | 0.449 | 0.039 | -0.143 | 0.860 |
| | p | 0.798 | **<0.001** | 0.759 | 0.265 | **<0.001** |

*(r: correlation coefficient, Independent variables: age, radiological tumour volume, pathological tumor volume, Dependent variables: Duration of Operation, amount of bleeding, Duration of Hospital Stay)*

**Table 5.** Multiple linear regression analysis to investigate the effect of other parameters on operation time

| **Variables** | **B** | **Std. Error** | **β** | **t** | **p** | **95% Confidence Interval** |
|---|---|---|---|---|---|---|
| **(Constant)** | 59.014 | 9.993 | | 5.906 | <0.001 | 38.997 to 79.031 |
| **Amount of Bleeding (ml)** | 0.145 | 0.078 | 0.217 | 1.857 | 0.069 | -0.11 to 0.302 |
| **Radiological Tumour Volume (cc)** | -0.226 | 0.190 | -0.326 | -1.190 | 0.239 | -0.605 to 0.154 |
| **Pathological Tumour Volume (cc)** | 0.720 | 0.230 | 0.837 | 3.317 | **0.003** | 0.260 to 1.180 |
| **Age** | -0.296 | 0.154 | -0.213 | -1.926 | 0.059 | -0.605 to 0.012 |
| **Hormone function** | 5.487 | 4.107 | 0.157 | 1.336 | 0.187 | -2.741 to 13.715 |
| **Pathological type** | 0.356 | 4.389 | 0.010 | 0.081 | 0.936 | -8.437 to 9.149 |
| **Dependent variable: Duration of Operation (min)** | | | | | | |
| **R:0.634** | **$R^{2:}$ 0.402** | **F: 6.280** | **p<0.001** | **Durbin-Watson: 2.361** | | |

**Table 6.** Multiple linear regression analysis to investigate the effect of other parameters on amount of bleeding

| **Variables** | **B** | **Std. Error** | **β** | **t** | **p** | **95% Confidence Interval** |
|---|---|---|---|---|---|---|
| **(Constant)** | -20.046 | 20.936 | | -0.957 | 0.342 | -61.986 to 21.894 |
| **Duration of Operation (min)** | 0.399 | 0.215 | 0.267 | 1.857 | 0.069 | -0.032 to 0.830 |
| **Radiological Tumour Volume (cc)** | -2.212 | 0.317 | -0.205 | -0.668 | 0.507 | -0.847 to 0.423 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Pathological Tumour Volume (cc)** | -0.139 | 0.412 | -0.108 | -0.336 | 0.738 | -0.964 to 0.687 |
| **Age** | 0.572 | 0.252 | 0.276 | 2.271 | **0.027** | 0.067 to 1.077 |
| **Hormone function** | 4.891 | 6.887 | 0.094 | 0.710 | 0.481 | -8.906 to 18.687 |
| **Pathological type** | 16.981 | 6.916 | 0.307 | 2.455 | **0.017** | 3.127 to 30.835 |

**Dependent variable: Amount of Bleeding (ml)**

**R:0.513 $R^{2:}$ 0.263 F: 3.337 p=0.007 Durbin-Watson: 2.096**

## 3. Results

The mean age of the 63 participants in the study was 55.38±12.68 years and there was no statistically significant difference between the groups (p=0.248, p=0.692, respectively). In the hormone-functional group, 16 (53.2%) patients presented symptomatically, statistically higher than the hormone-non-functional group (p=0.022) (Table 1). A total of 3 patients developed postoperative complications and all of whom were treated medically.

The mean duration of operation was 67.54±17.61 for all patients and was statistically significantly higher in the group with malignant pathology (p=0.041). The mean intraoperative blood loss was 61.48±26.31 cc and was significantly higher in the malignant group (p=0.014) (Table 2). The mean length of hospital stay was 3.81±1.50 days, significantly higher in the functional group (p=0.021) (Table 2). Radiological and pathological tumour volumes were significantly higher in the non-functional group and the group with malignant pathology (p<0.001, p=0.005, p=0.012, p=0.007 respectively) (Table 1,2).

When hormone-functional patients were analysed, pheochromocytoma was found in 10 patients, Cushing's syndrome in 12 patients, and Conn's syndrome in 8 patients. When the subtypes of malignant masses were examined, adrenocortical carcinoma was found in 10 patients, metastatic tumour in 7 patients, malignant pheochromocytoma in 2 patients, malignant mesenchymal tumour in 1 patient and malignant schwannoma in 1 patient. In the comparisons regarding the subtypes of hormonal functional adrenal masses, the operation time in Conn syndrome was shorter than the other two groups, and the radiological and pathological tumour volumes in Pheochromocytoma were higher than the other 2 groups (p = 0.038, p = 0.004, p = 0.007, respectively) (Table 3).

In the correlation analysis between age, duration of operation, amount of bleeding, length of hospital stay, and radiological and pathological tumour volume, a strong positive correlation was found between radiological and pathological tumour sizes, which was statistically significant (r=0.860, p<0.001). In particular, there was a moderate positive correlation between pathological tumour size and duration of operation, which was statistically significant (r=0.449, p<0.001). Correlations of other parameters were given in detail in the table (Table 4).

Independent factors affecting operation time were examined using multiple linear regression analysis (enter method). The model was statistically significant (F=6.280, p<0.001) and explained 40% of the variance in operation time, with no significant issues of autocorrelation (Durbin-Watson=2.361). Among the independent variables included in the analysis, only pathological tumor volume was a significant predictor of operation time. An increase of 1 cc in pathological tumor volume was associated with a 0.72-minute increase in operation time (Table 5).

Independent factors affecting bleeding were also evaluated using multiple linear regression (enter method). The model was statistically significant (F=3.337, p=0.007) and explained 26% of the variance in bleeding, with no significant issues of autocorrelation (Durbin-Watson=2.096). In this analysis, both pathological tumor type and age were found to be significant predictors of bleeding. Specifically, a malignant tumor type was associated with a 16.98 cc increase in bleeding, while each

additional year of patient age was associated with a 0.57 cc increase in bleeding (Table 6).

## 4. Discussion

Adrenalectomy operations have a long history. To date, achieving more successful outcomes has consistently been the goal through the provision of appropriate medication and the incorporation of minimally invasive techniques into surgical procedures. In this direction, surgical approaches based on laparotomy are largely replaced by laparoscopy, a minimally invasive technique. Laparoscopic adrenalectomy offers several advantages over open surgery, including a shorter operation time, less blood loss, reduced hospital stay, lower complication rates, less postoperative pain, faster recovery to normal activities, and better cosmetic results. Laparoscopic adrenalectomy has become the standard approach in the surgical treatment of most adrenal masses for these reasons and with successful results (2-4, 10).

Although it is considered a minimally invasive procedure, serious complications may develop during laparoscopic adrenalectomy operations. These complications are reported as vascular, spleen, liver and pleura injuries (11). Especially in the last 20 years, with the development of laparoscopic instrument technologies and the increase in surgical knowledge, experience, and expertise, there has been a significant decrease in complication rates (10, 12). Moreover, identifying patient groups suitable for laparoscopic adrenalectomy and analysing the patient variables that influence the success of the procedure, based on data from previous operations and advancements in imaging technologies, have consistently been subjects of research. When the literature is reviewed, the success criteria for laparoscopic adrenalectomy operations, as in all surgical interventions, can be listed as complication status, amount of intraoperative bleeding, converting to open surgery, operation time and hospital stay (13).

The literature shows that adrenal masses appear as benign lesions with a rate of approximately 65-83% according to preoperative evaluation and pathology results (14, 15). A total of 42 of 63 patients who underwent transperitoneal laparoscopic adrenalectomy in our study were found to have benign lesions (66%). In our study, hormone activity was found in 30 out of 63 patients and 53.2% of the patients in the hormone-functional group visited symptomatically and this was statistically significantly higher than the non-functional group. This was explained by the clinical changes that occur in the patient as a result of hormone activity and was in line with the literature (16). Similarly, the length of hospital stay was found to be statistically significantly higher in this group. There was no statistically significant difference between the hormone-functional group and the non-functional group in terms of complications, duration of operation and intraoperative bleeding parameters. Functional group, the tumour volume was found to be statistically significantly lower. When analysed in light of these data, it would be rational to associate the longer hospitalisation periods observed in the functional group with the clinical effects of hormone activity on the patient rather than problems related to the surgical procedure.

In our study, diabetes mellitus (DM) and hypertension (HT) rates were significantly higher in the hormone-functional group as expected. This is thought to develop secondary to impaired metabolic status due to hormone activity. Studies have shown that laparoscopic adrenalectomy results in lower morbidity and mortality, particularly in cases of Cushing's syndrome, where impaired wound healing, inadequate immune response, and obesity are common issues (17, 18). In our study, there was no significant finding between the clinical data of the groups regarding Cushing's syndrome. In evaluating hormone functional group subtypes, the operation duration was found to be shorter in patients with Conn's syndrome compared to the other two groups. There was no study which drew attention to such a situation in the literature.

Some studies have reported high rates of converting to open surgery and significantly longer durations of operation in laparoscopic surgery for pheochromocytoma cases. This is associated with difficult intraoperative haemodynamic stabilisation and bleeding due to increased pathological vascularisation. Some studies have shown a significant increase in the length of hospital stay after adrenalectomy for pheochromocytoma. In fact, in line with these studies, it has been suggested that open surgical approaches would be more beneficial in cases larger than 5 cm (19, 20). However, recent studies argue that the laparoscopic method allows intervention to vascular structures without mobilisation of adrenal tissue and causes very low catecholamine discharge. In parallel with this, studies reporting the high efficacy of laparoscopic adrenalectomy for phaeochromocytoma are also emerging. This method, initially performed in

selected mass-size cases, can also be successfully performed in 10-14 cm adrenal masses now. Although it is associated with high rates of conversion to open surgery, laparoscopic adrenalectomy is recognised as an efficient method in catecholamine-secreting adrenal masses (16, 21-23).

In our study, although radiological and pathological tumour volumes were higher in pheochromocytoma patients compared to the other 2 groups, there was no significant difference in duration of operation, length of hospital stay and intraoperative bleeding parameters. These findings revealed that high rates of conversion to open surgery as well as long duration of operations and postoperative medical care needs reported in the literature were similar in pheochromocytoma patients with other groups as an important result of our study. However, because a small number of cases that were converted to open surgery were excluded from the study due to reasons arising from the design of our study, the rates of conversion to open surgery could not be evaluated.

In the literature, open surgical approaches for the treatment of adrenal masses are gradually being replaced by minimally invasive methods, primarily laparoscopic adrenalectomy. However, disputable issues regarding patient selection remain significant. Especially the malignant character and size of the mass cause disagreement about the surgical method to be chosen. These two methods are often compared, especially in terms of oncological effectiveness, surgical parameters and the development of complications. In some clinical opinions, laparoscopic approaches are not recommended in the case of suspected malignancy in an adrenal mass and this is considered an indication for laparotomy (24, 25). However, there is no clear evidence in the literature that malignancy is a risk factor for converting to open surgery. Moreover, a definite contraindication limit for mass size in laparoscopic adrenalectomy has not been determined (26). The results of our study indicated that the laparoscopic approach was successfully performed with low complication rates and rates of conversion to open surgery, although longer duration of operation and higher intraoperative bleeding amount were found in adrenal masses with malignant characteristics.

In many studies on malignant adrenal masses, open and laparoscopic techniques have been analysed and similar surgical and oncological results have been demonstrated (20, 27). In their study comparing open and laparoscopic adrenalectomy, Brix et al. reported similar mortality and metastasis-free survival for both techniques in adrenal malignancies smaller than 10 cm and suggested that both techniques were oncologically equivalent (28). In another study, no correlation was reported between mass size and surgical parameters in laparoscopic adrenalectomy operations performed in masses up to 8 cm, whereas there was an increase in the amount of intraoperative bleeding, duration of operation and prolonged hospital stay in masses larger than 8 cm (29). In a study investigating the risk of transition of adrenal mass size to open surgery, the risk of conversion to open surgery was shown to increase in masses larger than 5.3 cm (13). Although patients who had a conversion to open surgery were excluded from our study, the duration of the operation was observed to be prolonged as the tumour size increased, but the amount of bleeding and length of hospital stay were not related to tumour size.

Besides the large tumour volumes, the duration of the operation and intraoperative bleeding amount were significantly higher in the malignant group. The fact that the amount of intraoperative bleeding was high in malignant adrenal tumours however no relationship could be identified between tumour sizes and bleeding in our study is noteworthy. This may be attributed to the neovascularisation in the content of the malignant mass rather than the size of the tumour (30). Due to the observation of longer operation times and increased intraoperative bleeding in malignant masses, it is expected that patients with longer operation times will experience more bleeding.

There are some limitations of our study. The most significant limitations of this study are the relatively small number of patients and its single-centre design. However, the exclusion criteria applied for study homogenization led to this situation. While the single-centre nature of the study may appear to be a limitation, the fact that all operations were performed by surgeons with the same level of experience using the same surgical technique enhanced the standardization of the study.

## 5. Conclusion

Laparoscopic adrenalectomy is a minimally invasive surgical technique used in the treatment of adrenal masses and provides successful surgical results. The parameters of the operation are influenced by the morphological and functional characteristics of the mass. While increased mass sizes were observed in both malignant masses and pheochromocytomas,

prolonged operation times and increased amounts of bleeding were only seen in malignant masses. It is esential for surgeons performing the operation to be aware that they may encounter varying clinical presentations both during and after the procedure, depending on the morphological and functional characteristics of the mass.

## REFERENCES


1. Thornton J. Abdominal nephrectomy for large sarcoma of the left suprarenal capsule: recovery. Trans Clin Soc Lond. 1890;23:150-3.
2. Gagner M. Laparoscopic adrenalectomy in Cushing's syndrome and pheochromocytoma. N Engl J Med. 1992;327:1033.
3. Ginzberg SP, Gasior JA, Kelz LR, Passman JE, Ballester JMS, Roses RE, et al. Adrenalectomy approach and outcomes according to surgeon volume. The American Journal of Surgery. 2024;229:44-9.
4. Yip L, Duh Q-Y, Wachtel H, Jimenez C, Sturgeon C, Lee C, et al. American Association of Endocrine Surgeons guidelines for adrenalectomy: executive summary. JAMA surgery. 2022;157(10):870-7.
5. Al-Jalabneh T, Al-Shawabkeh O, Al-Gwairy I, Abu-Zeitoun O, Al-Njadat I, Al-Soudi M, et al. Laparoscopic versus open adrenalectomy: a retrospective comparative study. Medical Archives. 2021;75(1):41.
6. Mete O, Erickson LA, Juhlin CC, de Krijger RR, Sasano H, Volante M, et al. Overview of the 2022 WHO classification of adrenal cortical tumors. Endocrine pathology. 2022;33(1):155-96.
7. Jing Y, Hu J, Luo R, Mao Y, Luo Z, Zhang M, et al. Prevalence and characteristics of adrenal tumors in an unselected screening population: a cross-sectional study. Annals of internal medicine. 2022;175(10):1383-91.
8. Alshahrani MA, Bin Saeedan M, Alkhunaizan T, Aljohani IM, Azzumeea FM. Bilateral adrenal abnormalities: imaging review of different entities. Abdominal Radiology. 2019;44:154-79.
9. Prakobpon T, Santi-Ngamkun A, Usawachintachit M, Ratchanon S, Sowanthip D, Panumatrassamee K. Laparoscopic transperitoneal adrenalectomy in the large adrenal tumor from single center experience. BMC surgery. 2021;21:1-9.
10. Conzo G, Patrone R, Flagiello L, Catauro A, Conzo A, Cacciatore C, et al. Impact of current technology in laparoscopic adrenalectomy: 20 years of experience in the treatment of 254 consecutive clinical cases. Journal of Clinical Medicine. 2023;12(13):4384.
11. Fouche D, Chenais G, Haissaguerre M, Bouriez D, Gronnier C, Collet D, et al. Risk factors for intraoperative complications, postoperative complications, and prolonged length of stay after laparoscopic adrenalectomy by transperitoneal lateral approach: a retrospective cohort study of 547 procedures. Surgical Endoscopy. 2023;37(10):7573-81.
12. Bellantone R, De Crea C. Surgical procedure: adrenalectomy–indications, operative techniques and management of complications. Endocrine Surgery Comprehensive Board Exam Guide: Springer; 2022. p. 575-614.
13. Tiberio GAM, Solaini L, Arru L, Merigo G, Baiocchi GL, Giulini SM. Factors influencing outcomes in laparoscopic adrenal surgery. Langenbeck's archives of surgery. 2013;398:735-43.
14. Zacharias M, Haese A, Jurczok A, Stolzenburg J-U, Fornara P. Transperitoneal laparoscopic adrenalectomy: outline of the preoperative management, surgical approach, and outcome. European urology. 2006;49(3):448-59.
15. Nagesser SK, Kievit J, Hermans J, Krans HMJ, van de Velde CJ. The surgical approach to the adrenal gland: a comparison of the retroperitoneal and the transabdominal routes in 326 operations on 284 patients. Japanese Journal of Clinical Oncology. 2000;30(2):68-74.
16. Aydın YM, Günseren KÖ, Çiçek MÇ, Aslan ÖF, Gül ÖÖ, Cander S, et al. The effect of mass functionality on laparoscopic adrenalectomy outcomes. Langenbeck's Archives of Surgery. 2024;409(1):212.
17. Danwang C, Agbor VN, Bigna JJ. Obesity and postoperative outcomes of the patients with laparoscopic adrenalectomy: a systematic review and meta-analysis. BMC surgery. 2020;20:1-8.
18. Tullavardhana T. Laparoscopic adrenalectomy performed by a general surgeon on functioning adrenal tumors: Treatment outcomes and risk prediction of persistent hypertension. Qatar Medical Journal. 2024;2024(3):30.
19. Vidal O, Saavedra-Perez D, Martos JM, de la Quintana A, Rodriguez JI, Villar J, et al. Risk factors for open conversion of lateral transperitoneal laparoscopic adrenalectomy: retrospective cohort study of the Spanish Adrenal Surgery Group (SASG). Surgical endoscopy. 2020;34:3690-5.
20. Shen Z, Chen S, Wang S, Jin X, Chen J, Zhu Y, et al. Predictive factors for open conversion of laparoscopic adrenalectomy: a 13-year review of 456 cases. Journal of endourology. 2007;21(11):1333-8.
21. McKinlay R, Mastrangelo Jr MJ, Park AE. Laparoscopic adrenalectomy: indications and technique. Current surgery. 2003;60(2):145-9.
22. Li J, Wang Y, Chang X, Han Z. Laparoscopic adrenalectomy (LA) vs open adrenalectomy (OA) for pheochromocytoma (PHEO): a systematic review and meta-analysis. European Journal of Surgical Oncology. 2020;46(6):991-8.
23. Fu S-Q, Wang S-Y, Chen Q, Liu Y-T, Li Z-L, Sun T. Laparoscopic versus open surgery for pheochromocytoma: a meta-analysis. BMC surgery. 2020;20:1-11.
24. Coste T, Caiazzo R, Torres F, Vantyghem MC, Carnaille B, Pattou F, et al. Laparoscopic adrenalectomy by transabdominal lateral approach: 20 years of experience. Surgical endoscopy. 2017;31:2743-51.

25. Donatini G, Caiazzo R, Do Cao C, Aubert S, Zerrweck C, El-Kathib Z, et al. Long-term survival after adrenalectomy for stage I/II adrenocortical carcinoma (ACC): a retrospective comparative cohort study of laparoscopic versus open approach. Annals of surgical oncology. 2014;21:284-91.
26. Sturgeon C, Kebebew E. Laparoscopic adrenalectomy for malignancy. Surgical Clinics. 2004;84(3):755-74.
27. Kastelan D, Knezevic N, Zibar Tomsic K, Alduk AM, Kakarigi L, Kastelan M, et al. Open vs laparoscopic adrenalectomy for localized adrenocortical carcinoma. Clinical endocrinology. 2020;93(4):404-8.
28. Brix D, Allolio B, Fenske W, Agha A, Dralle H, Jurowich C, et al. Laparoscopic versus open adrenalectomy for adrenocortical carcinoma: surgical and oncologic outcome in 152 patients. European urology. 2010;58(4):609-15.
29. Castillo OA, Vitagliano G, Secin FP, Kerkebe M, Arellano L. Laparoscopic adrenalectomy for adrenal masses: does size matter? Urology. 2008;71(6):1138-41.
30. Sharma S, Sharma M, Sarkar C. Morphology of angiogenesis in human cancer: a conceptual overview, histoprognostic perspective and significance of neoangiogenesis. Histopathology. 2005;46(5):481-9.