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Surgical Outcomes of Adrenal Mass Management: A Retrospective Analysis

Adrenal Kitle Tedavisinde Cerrahi Sonuçlar: Retrospektif Bir Analiz

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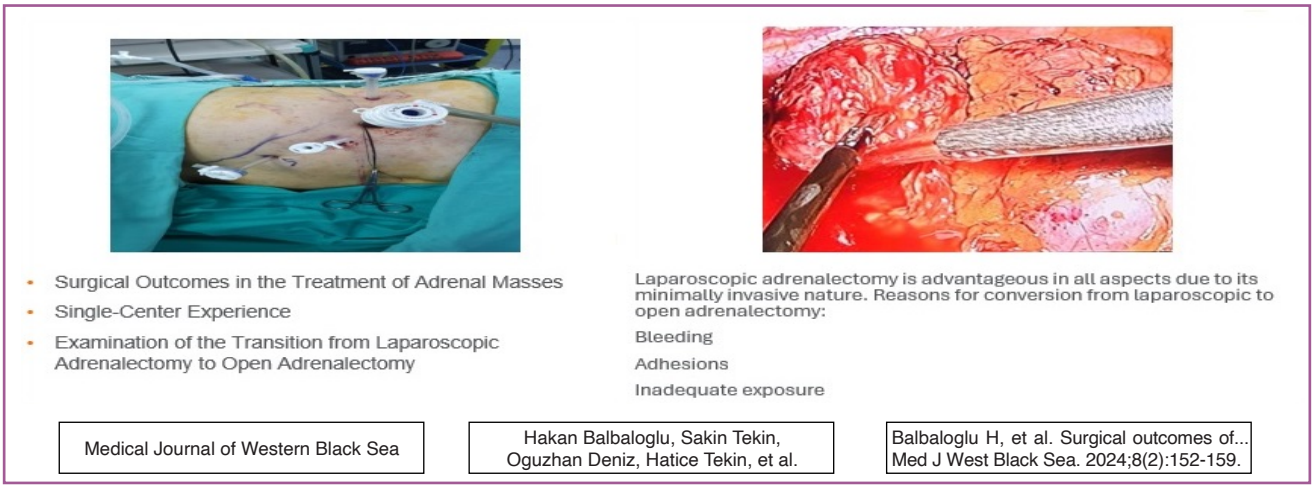
GRAPHICAL ABSTRACT



ABSTRACT

Aim: The shift towards laparoscopic adrenalectomy in treating adrenal tumors marks a significant advancement due to its minimally invasive nature, providing enhanced patient outcomes including reduced pain, shorter hospital stays, and lower complication rates compared to open adrenalectomy. This study aims to enrich the literature by presenting a detailed analysis of our adrenalectomy experiences, focusing on patient outcomes, perioperative metrics, and complication rates, to underscore the evolution of our surgical techniques and their significance in enhancing patient care in the realm of adrenal tumor management.

Material and Methods: Conducting a retrospective analysis at Zonguldak Bülent Ecevit University Hospital, we examined the outcomes, complications, and perioperative metrics of adrenalectomies. Out of 31 laparoscopic adrenalectomy patients, 14 underwent conversion to open adrenalectomy, focusing on assessing the procedure's effectiveness and the influence of different factors on surgical choices and results.

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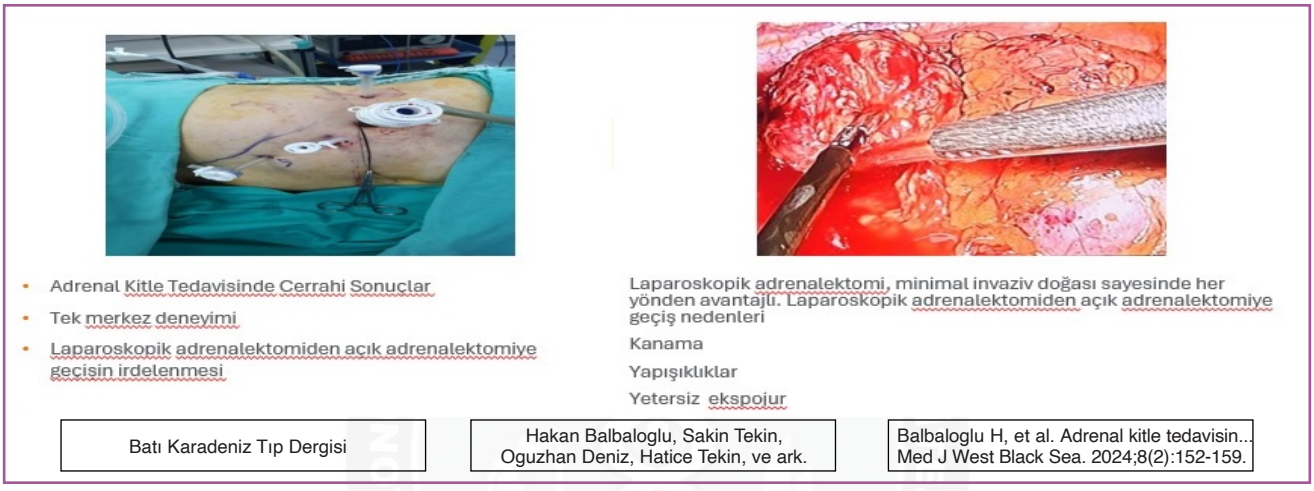
Results: Demographic analysis revealed no significant variance between patients continuing with laparoscopic adrenalectomy versus those converted to open adrenalectomy. The conversion was primarily driven by larger tumor sizes, emphasizing procedural difficulties. Predominant reasons for conversion included bleeding, insufficient exposure, and adhesions, indicating the technical intricacies and complication risks of laparoscopic adrenalectomy. This underscores the pivotal role of surgical skill in technique selection.

Conclusion: Despite the challenges, laparoscopic adrenalectomy stands as the preferred method for managing adrenal tumors, given its benefits over open adrenalectomy. The conversion to open adrenalectomy, heavily reliant on surgical expertise and faced intraoperative issues, highlights the imperative for mastery in laparoscopic adrenalectomy. Future research should focus on refining laparoscopic adrenalectomy methods, reducing conversions, and advancing patient care.

Keywords: Laparoscopic adrenalectomy, open adrenalectomy, adrenal tumors, surgical expertise

GRAFİKSEL ÖZET



ÖZ

Amaç: Adrenal tümörlerin tedavisinde laparoskopik adrenalektomiye geçiş, minimal invaziv doğası nedeniyle önemli bir ilerlemeye işaret etmekte ve açık adrenalektomiye kıyasla daha az ağrı, daha kısa hastanede kalış süresi ve daha düşük komplikasyon oranları gibi gelişmiş hasta sonuçları sağlamaktadır. Bu çalışma, cerrahi tekniklerimizin gelişimini ve adrenal tümör yönetimi alanında hasta bakımını iyileştirmedeki önemini vurgulamak için hasta sonuçlarına, perioperatif ölçümlere ve komplikasyon oranlarına odaklanarak adrenalektomi deneyimlerimizin ayrıntılı bir analizini sunarak literatürü zenginleştirmeyi amaçlamaktadır.

Gereç ve Yöntemler: Zonguldak Bülent Ecevit Üniversitesi Hastanesi'nde retrospektif bir analiz yaparak, adrenalektomilerin sonuçlarını, komplikasyonlarını ve perioperatif ölçümlerini inceledik. 31 laparoskopik adrenalektomi hastasından 14'ünde açık adrenalektomiye dönüşüm yapıldı ve prosedürün etkinliğini ve farklı faktörlerin cerrahi seçimler ve sonuçlar üzerindeki etkisini değerlendirmeye odaklanıldı.

Bulgular: Demografik analiz, laparoskopik adrenalektomi ile devam eden hastalar ile açık adrenalektomiye dönüştürülenler arasında anlamlı bir farklılık olmadığını ortaya koydu. Dönüşüm öncelikle daha büyük tümör boyutlarından kaynaklanmış ve prosedürel zorlukları vurgulamıştır. Dönüşümün başlıca nedenleri arasında kanama, yetersiz ekspojur ve yapışıklıklar yer almakta olup, bu durum laparoskopik adrenalektominin teknik karmaşıklıklarını ve komplikasyon risklerini göstermektedir. Bu durum, cerrahi becerinin önemli rolünün altını çizmektedir.

Sonuç: Zorluklarına rağmen laparoskopik adrenalektominin, açık adrenalektomiye göre avantajları göz önüne alındığında, adrenal tümörlerin tedavisinde tercih edilen yöntem olarak durmaktadır. Cerrahi uzmanlığa büyük ölçüde bağımlı olan ve intraoperatif sorunlarla karşılaşan açık adrenalektomiye dönüşüm, laparoskopik adrenalektomide ustalaşmanın zorunluluğunu vurgulamaktadır. Gelecekteki araştırmalar laparoskopik adrenalektomi yöntemlerini iyileştirmeye, açık cerrahiye dönüşümleri azaltmaya ve hasta bakımını ilerletmeye odaklanmalıdır.

Anahtar Sözcükler: Laparoskopik adrenalektomi, açık adrenalektomi, adrenal tümörler, cerrahi uzmanlık

INTRODUCTION

The past few decades have marked a significant evolution in the surgical management of adrenal tumors. Initially, open adrenalectomy was the primary technique for excising adrenal masses, offering a direct method to remove both benign and malignant lesions (1). However, the introduction of laparoscopic adrenalectomy under the leadership of Gagner et al. in 1992 opened a new chapter in the treatment of adrenal diseases (2). This minimally invasive approach, encompassing transperitoneal techniques, has since become the preferred standard for most adrenal tumor surgeries. In addition, the endoscopic retroperitoneal adrenalectomy (posterior approach), pioneered by Mercan et al., is rapidly gaining popularity due to its numerous benefits. This technique is particularly preferred for patients requiring bilateral adrenalectomy or unilateral adrenalectomy for benign adenomas smaller than 5 cm (3).

These advantages include reduced operative morbidity, decreased postoperative pain, shorter hospital stays, and better cosmetic outcomes, making laparoscopic adrenalectomy more favorable than open adrenalectomy (4). Despite its benefits, laparoscopic adrenalectomy is recognized as technically demanding, requiring substantial surgical skill and expertise. Proficiency in laparoscopic adrenalectomy typically emerges after 20 to 40 cases, underscoring the importance of experience in optimizing outcomes (5-7). The continuous advancements in surgical techniques and technology have further enhanced the safety and effectiveness of these procedures.

This study aims to contribute to the literature by detailing our initial decade of experience with adrenalectomies, evaluating outcomes, perioperative data, and complication rates. Through this, we provide a comprehensive overview of our surgical practice in managing adrenal tumors, illustrating the procedural advancements and their impact on patient care.

Our findings aim to offer valuable insights for surgical teams and contribute to the ongoing improvements in adrenal surgery.

MATERIAL and METHODS

This retrospective study was conducted at the General Surgery Clinic of Zonguldak Bülent Ecevit University Hospital, reviewing the medical records of patients diagnosed with adrenal masses who underwent adrenalectomy between 2016 and 2024. This study was conducted in line with the ethical standards set by the National Institutes of Health Guidelines for the care and use of laboratory animals. Approval for the study was obtained from the Ethics Review Board of Zonguldak Bülent Ecevit University (protocol no: 2024/02-5). Images are used in the article with the patient's consent in compliance with personal data protection regulations.

This study was designed to share insights from our encounters with adrenal tumors within an educational healthcare setting, characterized by the collaboration between surgeons of differing expertise levels. However, a significant proportion of cases had to be excluded from the retrospective review because they did not meet the inclusion criteria or because of incomplete records. Only patients with accessible and complete records were included in the study. The data retrospectively analyzed included age, sex, dimensions of the adrenal mass, hormonal activity, operation duration, conversion rates to open surgery, histopathological findings, intraoperative and postoperative complications, and mortality rates. Primary surgical indications encompassed hormonally active tumors, tumors larger than 4 cm, increasing tumor size upon follow-up, and cases suspected of malignancy based on radiological imaging. In line with the 2023 guidelines from the European Society of Endocrinology on the management of adrenal incidentalomas, it has been emphasized that not only the size of the tumor but also its radiological characteristics and appearance should be considered (8). Therefore, as part of the comprehensive assessment for surgical intervention, it is also necessary to evaluate heterogeneity, irregular borders, and rapid tumor growth on imaging. The diagnosis of adrenal tumors was established through computed tomography (CT) and magnetic resonance imaging (MRI). Those who did not have an indication for adrenectomy at the initial evaluation underwent magnetic resonance imaging at six-monthly intervals, with annual imaging thereafter. During follow-up, an increase of more than 20% and at least 5 mm in the largest diameter of the lesion compared to the previous imaging, or the lesion exceeding 4 cm in its largest diameter, was considered a significant growth. In patients whose hormonal test results were within the normal range at baseline evaluation, no further hormonal tests were performed at follow-up examinations unless new signs of endocrine hyperfunction were detected during clinical evaluation. Preoperative and postoperative coordination with the endocrinology department was essential for the management of hormonally active adrenal tumors. A multidisciplinary endocrine board determined decisions regarding surgery.

Evaluation of the Functional Status of Adrenal Masses

In our Endocrinology department, a detailed examination has been conducted on the functional status of adrenal masses, both those identified through imaging conducted due to suspicion of adrenal disease and those found incidentally. This study comprehensively explains adrenal masses' etiology and functional activity. All patients were evaluated based on two primary criteria regarding the presence of adrenal masses: Determination of pheochromocytoma

Figure 1: Transabdominal Laparoscopic Approach for Adrenalectomy.
A. Trocar placement markings for Transabdominal Laparoscopic Adrenalectomy, B. Appearance of excised adrenal tumors.This image is used in the article with the patient's consent in compliance with personal data protection regulations.

risk through plasma and/or 24-hour urinary metanephrine and normetanephrine levels and investigation of endogenous hypercortisolism through basal cortisol levels and the 1 mg dexamethasone suppression test. Patients with a history of hypertension and/or hypokalemia were assessed for primary hyperaldosteronism by measuring plasma renin and aldosterone levels. For those who were normotensive and normokalemic and had no history of hypokalemia, the likelihood of primary hyperaldosteronism was considered low. Consequently, further evaluation for this condition was not deemed necessary. After initial testing, advanced tests were conducted on patients who showed signs of endocrine hyperfunction. These tests aimed to confirm the diagnosis and better understand the etiology of adrenal masses.

Surgical Technique

A transabdominal laparoscopic approach was primarily chosen for all patients. Patients were positioned in a semi-flank position (either left or right side) to facilitate the procedure. The pneumoperitoneum was established using a Veress needle. The surgical procedure typically utilized four ports: one 10-mm port for the camera, one 5-mm port for the surgeon's right hand, and two 5-mm ports for additional instruments (Figure 1).

In certain cases, conversion to open adrenalectomy was necessitated due to reasons such as the inability to elucidate anatomical planes, the presence of intra-abdominal adhesions, or uncontrolled bleeding (Figure 2). All patients were initiated on a regular diet and mobilized on the first postoperative day. An abdominal drain was placed in all patients.

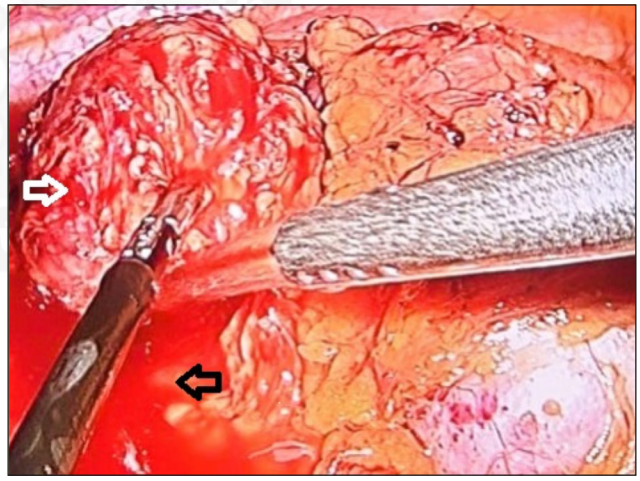


Figure 2: Uncontrolled Bleeding During Laparoscopic Adrenalectomy.
White arrow: Adrenal tumor, Black arrow: Hemorrhage area
This image is used in the article with the patient's consent in compliance with personal data protection regulations.

Statistical Analysis

The analyses were conducted using SPSS (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL) version 22. This study presents descriptive data as counts and percentages for categorical variables and means ± standard deviations (Mean ± SD) for continuous variables. The comparison of categorical variables between groups was performed using the Pearson Chi-square test, and Fisher-Freeman-Halton Chi-square test. The normality of distribution for continuous variables was assessed with the Kolmogorov-Smirnov test. The student's t-test was utilized to compare the two groups. A p-value of <0.05 was considered statistically significant.

RESULTS

This study enrolled 31 patients, 17 (54.8%) undergoing laparoscopic adrenalectomy and 14 (45.2%) converted to open adrenalectomy. Females constituted 47.1% of the laparoscopic adrenalectomy group and 57.1% of the open adrenalectomy group. The difference in gender distribution between the two groups was not statistically significant (p = 0.576). Age analysis revealed a mean age of 54.2 ± 12.8 years in the laparoscopic adrenalectomy group and 55.9 ± 13.0 years in the open adrenalectomy group, indicating no significant difference in age between the groups (p = 0.730). Significantly higher values were observed in the open adrenalectomy group across several parameters than in the laparoscopic adrenalectomy group. These included the preoperative radiological size of adrenal masses (p = 0.003), pathological size (p = 0.005), duration of hospital stays (p < 0.001), and drain withdrawal time (p < 0.001). Wound site infection was observed in 35.7% of the open adrenalectomy group, while it was not observed in the laparoscopic adrenalectomy group, and a significant difference was detected between the groups (p=0.012) (Table 1).

Among patients diagnosed with pheochromocytoma, 66.7% required conversion to open surgery due to bleeding and 33.3% due to insufficient exposure. For those with adrenocortical adenoma, conversions were attributed to bleeding (50%), insufficient exposure (25%), and adhesions (25%).

Table 1: Comparison of all characteristics of the groups

		LA (n=17)	OA (n=14)	p
		n (%)	n (%)	
Gender*	Female	8 (47.1)	8 (57.1)	0.576**
	Male	9 (52.9)	6 (42.9)	
Age, (Year±SD) Median (Min-Max)		54.2±12.8 54.0 (31.0-76.0)	55.9±13.0 60.0 (25.0-74.0)	0.730***
Pathological diagnosis*	Pheochromocytoma	9 (52.9)	6 (42.9)	0.431****
	Adrenocortical adenoma	4 (23.5)	4 (28.6)	
	Myelolipoma	4 (23.5)	2 (14.3)	
	Adrenocortical carcinoma	0 (.0)	2 (14.3)	
Preop Radiologically determined size (mm±SD) Median (Min-Max)		27.8±11.9 26.0 (12.0-45.0)	44.6±17.4 40.0 (20.0-80.0)	**0.003****
Pathological size (mm±SD) Median (Min-Max)		28.5±13.2 30.0 (12.0-52.0)	44.9±16.9 40.0 (19.0-70.0)	**0.005****
Length of hospital stay (day±SD) Median (Min-Max)		3.4±.8 3.0 (2.0-5.0)	6.8±1.1 7.0 (5.0-9.0)	**<0.001****
Wound site infection*	Yes	0 (0)	5 (35.7)	**0.012****
	No	17 (100.0)	9 (64.3)	
Reason for transition to (OA) *	Bleeding	-	9 (64.3)	-
	Insufficient exposure		4 (28.6)	
	Adhesions		1 (7.1)	
Drain withdrawal time (day±SD) Median (Min-Max)		2.1±.4 2.0 (1.0-3.0)	4.5±.5 4.5 (4.0-5.0)	**<0.001****
Operation side*	Right	10 (58.8)	8 (57.1)	0.925**
	Left	7 (41.2)	6 (42.9)	

*Data are expressed as n(%)**Pearson Chi-Square, ***Student t-test, and **** Fisher-Freeman-Halton Chi-Square test were used.
LA: laparoscopic adrenalectomy, **OA:** open adrenalectomy

Table 2: Comparative Analysis of Reasons for Conversion from Laparoscopy to Open Surgery Based on Pathological Diagnosis and Gender

Complications Based on Pathological Diagnosis and Gender		Bleeding	Insufficient exposure	Adhesions	p**
Pathological diagnosis *	Pheochromocytoma	4 (66.7)	2 (33.3)	0 (0.0)	0.856
	Adrenocortical adenoma	2 (50.0)	1 (25.0)	1 (25.0)	
	Myelolipoma	1 (50.0)	1 (50.0)	0 (0.0)	
	Adrenocortical carcinoma	2 (100.0)	0 (0.0)	0 (0.0)	
Gender*	Female	4 (50.0)	3 (37.5)	1 (12.5)	0.748
	Male	5 (83.3)	1 (16.7)	0 (0.0)	

*Data are expressed as n(%). ** Fisher-Freeman-Halton Chi-Square test was used.

Myelolipoma conversions were evenly divided between bleeding and insufficient exposure at 50%. All patients with adrenocortical carcinoma underwent conversion exclusively due to bleeding. The analysis showed no significant difference in the reasons for conversion among the different pathological diagnoses (p = 0.856). Conversion reasons varied slightly between genders, with bleeding (50%), insufficient exposure (37.5%), and adhesions (12.5%) being the reasons among women, and bleeding (83.3%) and insufficient exposure (16.7%) among men, showing no significant gender difference (p = 0.748) (Table 2).

The distribution of diagnoses showed variability between genders, with 43.8% of women diagnosed with pheochromocytoma, equal to the percentage for adrenocortical adenoma, followed by myelolipoma and adrenocortical carcinoma at 6.3% each. Among men, diagnoses included pheochromocytoma (53.3%), myelolipoma (33.3%), adrenocortical carcinoma (6.7%), and adrenocortical adenoma (6.7%). This gender-based discrepancy in the diagnosis of adrenocortical adenoma contributed to a marginally significant difference in the distribution of diagnoses (p = 0.05). In the study group, no mortality was observed among the patients during follow-up period.

DISCUSSION

Compared to open adrenalectomy, laparoscopic adrenalectomy is associated with several advantages, such as reduced intraoperative blood loss, decreased postoperative morbidity, and shorter duration of hospital stay (9). Our findings, confirming expedited discharge for laparoscopic adrenalectomy patients, align with broader surgical observations. Surgeons may decide on open adrenalectomy as the planned procedure before surgery or may convert from laparoscopic surgery to open techniques during the operation. Hou et al. noted a 4.17% conversion rate, with factors like tumor size (>7 cm), transabdominal approach, pheochromocytoma presence, and malignancy increasing conversion risk (10). Thompson et al. reported a conversion rate of 5.6% from laparoscopic to open adrenalectomy in their study of 659 patients, highlighting large tumor size and the presence of malignant tumors as significant factors influencing the decision to convert (11). The ongoing debate about tumor size in laparoscopic adrenalectomy is complex.

Although the common guideline, supported by research from Staren and Prinz (12), Gupta et al. (13), and Ibragimovich et al. (14), suggests that laparoscopic adrenalectomy is best suited for tumors smaller than 8 cm, there are other studies by Fiori et al. (15), and Machado et al. (16) that show laparoscopy can also be safely and effectively used for significantly larger tumors. In our research, the median tumor size observed in patients undergoing laparoscopic adrenalectomy was 28.5±13.2mm, whereas it was significantly larger, at 44.9±16.9 mm, in those requiring conversion to open adrenalectomy. Consistent with our findings, the preoperative radiographic and pathologic sizes of the adrenal mass demonstrated significant differences, notably larger in the open adrenalectomy group than in the laparoscopic adrenalectomy group (p=0.003 for radiographic size, p=0.005 for pathologic size). On the other hand, in our study, there was no significant difference between pathologic diagnoses regarding the reason for conversion to open adrenalectomy (p=0.856).

One significant reason for converting from laparoscopic adrenalectomy to open adrenalectomy is encountering intraoperative complications. The most common complications in laparoscopic adrenalectomy involve vascular injuries, with occurrences of bowel, liver, spleen, pleural, and pancreatic injuries as well (17). Our investigation documented intraoperative complications in patients comprising six males and eight females. Statistical analysis revealed no significant correlation between the incidence of intraoperative complications and factors such as gender or localization.

Among the patients requiring conversion to open adrenalectomy, the predominant complications included bleeding (64.3%), insufficient exposure (28.6%), and adhesions (7.1%). Bleeding appears to be the most common reason for conversion to open surgery, and therefore, surgical experience is one of the most important reasons for conversion to open adrenalectomy. The investigation by Eto et

al. concluded that the learning curve for laparoscopic adrenalectomy levels off after the 42nd case, highlighting a reduction in operation times and blood loss, which signifies a surgeon's increased proficiency with the procedure (18). Existing literature suggests conversion rates from laparoscopic adrenalectomy to open adrenalectomy vary between 0% and 13% (19). However, our study identified a significantly higher conversion rate of 45%, which may reflect the varied experience levels of the surgeons involved. Upon closer examination of cases handled by surgeons with extensive experience in laparoscopic adrenalectomy, the conversion rate to open adrenalectomy aligns more closely with the standards reported in the literature. This alignment suggests that as surgeons surmount the learning curve, the likelihood of conversion diminishes, reinforcing the value of experience in achieving optimal surgical outcomes.

Weinandt et al. (20) have demonstrated that laparoscopic adrenalectomy can be conducted safely in patients over 75 years of age without an increase in postoperative morbidity. In our study, although the average age of patients undergoing open surgery rather than laparoscopy was higher, we contend that age should not be considered a hindrance to opting for laparoscopic procedures.

Our study further supports the significant role that minimally invasive procedures play in shortening hospital stays. Specifically, patients who underwent laparoscopic surgery had an average hospital stay of 3.4±0.8 days, in stark contrast to the 6.8±1.1 days observed in patients who were converted to open surgery. Notably, the increase in hospitalization duration for patients undergoing conversion to open adrenalectomy was statistically significant ($p<0.001$).

Zhang et al. (21) observed a shorter postoperative drainage tube retention duration in patients undergoing laparoscopic adrenalectomy. Consistent with these findings, our study also revealed that patients subjected to laparoscopic adrenalectomy experienced earlier removal of abdominal drains, averaging 2.1±0.4 days, compared to those who underwent open adrenalectomy.

This study has several limitations. Firstly, it employs a retrospective design with a small sample size, which may limit the generalizability of the findings. Secondly, the surgical procedures were performed by various surgeons, not all of whom possessed equal experience in laparoscopic adrenalectomy. This disparity in surgical expertise precludes an effective evaluation of the learning curve required for proficiency in this procedure. Additionally, variations in postoperative management practices, such as the timing of the initiation of oral feeding, the use of drains, and the timing of discharge, were observed among surgeons. These variations indicate that the individual surgeon's approach can significantly influence the duration of hospital stay.

In conclusion, laparoscopic adrenalectomy remains a superior surgical technique for managing adrenal masses, with its success and the decision to convert to open surgery heavily influenced by surgeon experience, intraoperative complications, and patient-specific factors. Future research with more extensive, prospective studies is warranted to explore the nuances of the learning curve and further validate the benefits of laparoscopic adrenalectomy, especially in complex cases and diverse patient populations.

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Author Contributions

Concept: **Hakan Balbaloglu,** Design: **Hakan Balbaloglu, Guldeniz Karadeniz Cakmak,** Data collection or processing: **Oguzhan Deniz, Hatice Tekin,** Analysis or Interpretation: **Sakin Tekin, Guldeniz Karadeniz Cakmak,** Literature search: **Hakan Balbaloglu, Guldeniz Karadeniz Cakmak,** Writing: **Hakan Balbaloglu, Mustafa Comert,** Approval: **Mustafa Comert.**

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Ethical Approval

This study was reviewed and approved by the Ethics Committee of Zonguldak Bülent Ecevit University (protocol no: 2024/02-5).

Review Process

Extremely and externally peer-reviewed.

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