Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2019;44(Suppl 1):391-399
DOI: 10.17826/cumj.570824

ARAŞTIRMA / RESEARCH

Comparison of laparoscopic and open surgical techniques in adrenal masses in terms of outcome

Adrenal kitlelerde laparoskopik ve açık cerrahi tekniklerin sonuç açısından karşılaştırılması

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Cukurova Medical Journal 2019;44(Suppl 1):391-399.

Abstract

Purpose: The aim of this study was to compare the results of conventional and laparoscopic adrenalectomy in adrenal mass cases operated on during a 9-year period.

Materials and Methods: A total of 81 patients who underwent adrenalectomy were included in the study. Patients were divided into two groups as; Group 1 - conventional surgery and Group 2 - laparoscopic surgery. Two groups were compared retrospectively on characteristics such as; age, sex, body mass index (BMI), American Society of Anesthesiologists' score (ASA), mass localization, mass size and hormonal activity of the mass, duration of operation, amount of bleeding in operation, duration of hospitalization, duration until food intake, perioperative mortality, early complications and readmission to hospital within 90 days.

Results: There were 22 patients in Group 1 and 59 patients in Group 2. No statistically significant difference was found between the groups in terms of age, sex, BMI, ASA score, tumor localization, indications for operation, postoperative complication, perioperative mortality and re-admittance within 90 days. The hormonal activity of the mass was higher and the mass was smaller in size in Group 2. The duration of operation (min), the amount of bleeding in the operation (ml), the duration until oral intake (days) and the length of hospital stay (days) were found to be statistically significantly higher in Group 1.

Conclusion: Laparoscopic adrenalectomy should be the preferred surgical method because of its short duration of operation, low blood loss, early onset of oral food intake and shorter hospital stay, as well as its safety.

Keywords: Surrenal, laparoscopy, minimally invasive surgery

Öz

Amaç: Bu çalışmada, 9 yıl içerisinde adrenal kitle nedeni ile ameliyat edilen olgularda konvansiyonel ve laparoskopik adrenalektominin sonuçlarının karşılaştırılması amaçlanmıştır.

Gereç ve Yöntem: Adrenalektomi uygulanan 81 hasta çalışmaya dahil edildi. Grup 1 konvansiyonel, Grup 2 Laparaskopik cerrahi olarak hastalar iki grupa ayrıldı. İki grup, yaş, cinsiyet, vücut kitle indeksi (VKİ), Amerikan anestezistler derneği skoru (ASA), kitle lokalizasyonu, kitle büyüklüğü ve kitlenin hormonal aktivitesi, operasyon süresi, operasyonda kanama miktarı, yatış süresi, gıdaya başlama süresi, perioperatif mortalite, erken dönem komplikasyonlar ve 90 gün içinde hastaneye tekrar başvuru gibi özellikleri esas alınarak retrospektif olarak karşılaştırıldı.

Bulgular: Grup 1'de 22, Grup 2'de 59 hasta mevcut idi. Gruplar arasında yaş, cinsiyet, VKİ, ASA skoru, tümör lokalizasyonu, operasyon endikasyonları, postoperatif komplikasyon, perioperatif mortalite ve 90 gün içinde tekrar başvuru açısından istatistiksel olarak anlamlı fark saptanmadı. Kitlenin hormonal aktivitesi Grup 2'de daha yüksek, boyutu ise daha küçük saptandı. Operasyon süresi (dak), ameliyatta kanama miktarı (ml), oral alım süresi (gün) ve hastanede yatış süresi (gün) Grup 1'de daha fazla ve istatiksel olarak anlamlı bulundu.

Sonuç: Laparoskopik adrenalektomi uygun hastalarda, kısa operasyon süresi, az kan kaybı, oral gıdaya erken başlama süresi ve daha kısa hastanede kalış süresi gibi avantajları, ayrıca güvenli olması nedeni ile tercih edilmesi gereken cerrahi yöntem olmalıdır.

Anahtar kelimeler: Sürrenal, laparoskopi, minimal invazif cerrahi

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Geliş tarihi/Received: 28.05.2019 Kabul tarihi/Accepted: 05.08.2019 Çevrimiçi yayın/Published online: 27.09.2019

INTRODUCTION

The adrenal glands are organs located in the retroperitoneum on the anterosuperior and medial sides of the kidneys[1]. Adrenal gland surgery is difficult and risky due to its relationship with the aorta, vena cava and kidney vessels[2]. Surrenal masses are pathologies with a high risk of malignancy and may present with different clinical, laboratory and radiological data. Today, with the introduction of high-tech radiological diagnostic methods and the development of diagnostic tests, there is a significant increase in the detection of adrenal gland masses[3,4]. These masses can be benign or malignant, and hormone active or non-active. The distinction of benign and malignant adrenocortical masses can be difficult. The anatomical changes caused by the existing pathology (cancer, bleeding, secretory nodule), the secretory changes caused by the nodules and the location of the mass play an important part in determining the surgical approach in adrenal masses[5].

The first operation for an adrenal cyst was performed by Pawlik in 1894. The first pheochromocytoma operation was performed in 1923[6]. Laparoscopic adrenalectomy (LA) was first performed by Gagner et al. in 1992. In 1995, Marcan and his colleagues described the technique of retroperitoneal laparoscopic adrenalectomy. LA is currently the preferred method for the surgical treatment of benign functional and non-functional adrenal masses. In recent years, indications have been extended by emphasizing that larger adrenal masses and metastases can be removed by laparoscopy[7-9].

In recent years, decreased analgesic need, less bleeding, lower complication rates and shorter hospital stay have been reported in LA compared to conventional surgery. Laparoscopic approach has become the gold standard[2,9-12].

In the study of Elfenbein et al there was a significantly higher 30-day postoperative morbidity in the open surgery group (18.8% vs 6.4%, $P < 0.01$). Median postoperative length of stay was also significantly longer in the open surgery group (5 vs 2 days, $P < 0.01$) and operative time (median, minutes) was also significantly longer in the open group (160 vs 130 minutes ($P<0.0001$)[13].

In the study of Zheng GY et al. on adrenocortical carcinoma, the open adrenalectomy (OA) group had larger mean maximum diameter of tumor (10.1±3.6 vs 6.3±2.2 cm) and lesser benefits in operative time, bleeding loss and postoperative hospital stay when compared to the laparoscopic group. Mean disease-free survival (DFS) of OA was 44.8±35.1 months, which was longer than 17.5±10.4 months of LA, and the rate of 2-year DFS after primary surgery in the open group was higher than in the laparoscopic group (61.1% vs 21.4%, respectively). Rates of 1- and 3-year DFS showed no significant difference[14].

The purpose of this study was to compare the effectiveness and outcome between LA and open adrenalectomy (OA) in the management of adrenal mass. In this study, we highlight the importance of a minimally invasive approach by reviewing the results of the studies in the literature, based on our results.

MATERIALS AND METHODS

The patients who were operated on for an adrenal mass in the ÇUFoM general surgery clinic between January 2011 and January 2019 were included in the study after obtaining the 86/39 numbered permission from Çukurova University Faculty of Medicine Ethics Committee on 08.03.2019. Our study was conducted in accordance with the Helsinki declaration. Informed consent could not be obtained from the patients because of the retrospective design of the study. A prospective database with patient files and hospital information system records was retrospectively reviewed. Information was obtained about the latest status of the patients via telephone. Patients who were operated on in the general surgery clinic due to a surrenal mass were included in the study. A total of 8 patients were excluded due to being in the pediatric age group, having incomplete information in their medical records and trauma.

A total of 81 patients were included in the study. The patients were divided into two groups as conventional approach and laparoscopic approach. The surgical approach was based on the surgeon's preference and experience. Conventional surgery was preferred in patients with a history of upper abdominal surgery and those with a mass above 10 cm in size.

Demographic characteristics, body mass index (BMI), American Society of Anesthesiologists' score (ASA), localization, size and hormone activity status of the mass, duration of operation, amount of intraoperative bleeding, postoperative complication, postoperative oral onset time, postoperative hospitalization duration, perioperative mortality,

readmission within 90 days and conversion to conventional surgery differences between the groups were analyzed.

Wound site infection was defined as a superficial or deep surgical site infection on the surgical incision according to the definition of the Centers for Disease Control (CDC)[15]. Oral intake without nausea or vomiting, pain control by oral analgesia and self-mobilization were the criteria of discharge and were similar among the groups. The operations were performed by surgeons who completed the laparoscopic surgical learning curve. Conversion to conventional surgery was defined as the making of an incision for any purpose other than removing the specimen or placing the port. Unplanned admission was defined as "an unplanned readmission to the hospital within the first 90 days after discharge". Mortality was defined as perioperative mortality within 30 days postoperatively or during hospital stay.

Preoperative preparation and indications for the operations

Adrenal masses were evaluated by the Endocrinology and Metabolism Clinic in terms of functionality. For the diagnosis of pheochromocytoma, 24-hour urinary methanephrine and normetanephrine, and in some cases vanillylmandelic acid, was studied. The patients who will be operated with the diagnosis of pheochromocytoma were treated with alpha blocker (doxazosin 2x4 mg) and beta blocker (propranolol 1x40 mg or metoprolol succinate 2x50 mg) before the operation for at least 2 weeks, for the hypertensive crisis which would occur during surgery.

For the diagnosis of Cushing's syndrome, basal plasma adrenocorticotropic hormone (ACTH) and cortisol levels were evaluated at 08:00 hours. Then 1mg dexamethasone suppression test (DST) was conducted. Cushing syndrome was not considered in patients with cortisol suppression (<1.8 mcg / dL) after DST. For the differential diagnosis of pseudo-Cushing in patients who did not have suppressed cortisol levels, 2 mg DST was performed. Cushing syndrome was diagnosed in patients who did have suppressed cortisol and who had a morning cortisol greater than 1.8 mcg/dL. 8 mg DST was performed to determine the source of hypercortisolemia. After the administration of 8 mg dexamethasone at 23:00, if the cortisol value at 8:00 in the morning was not suppressed by 50% and basal ACTH levels were low, the cases were accepted as adrenal originated Cushing syndrome. Plasma aldosterone and renin levels and aldosterone/renin ratio were evaluated in patients with hypopotassemia and hypertension to investigate primary hyperaldosteronism. NaCl loading test was applied to the cases with a high ratio (>30) and the cases with high aldosterone levels were diagnosed as primary hyperaldosteronism[16,17]. In preoperative imaging, computed tomography or magnetic resonance imaging with abdominal ultrasonography were used in all patients.

Management of patients during the perioperative period

All procedures were performed with lateral transperitoneal approach under general anesthesia. Anesthesia was provided by sevoflurane (1%) and oxygen (50%) inhalation supplemented with remifentanil infusion. Muscle relaxation during the operation was continued with rocuronium in accordance with the neuromuscular monitoring guide. In patients with pheochromocytoma, invasive arterial pressure was routinely monitored. Intraoperative hypertension was managed with nitroprusside (0.2-10 mg/kg/min) and short-acting beta-blockers (esmolol 50-300 mg/kg/min intravenously if necessary; dose 0.2-0.7 mg/kg/min if necessary). Intravenous dexmedetomidine infusion was added to obtain hemodynamic control in some patients.

Surgical technique

All patients had prophylactic 1g cefazolin administration during induction and varicose vein sock application for deep venous thrombosis prophylaxis. 30° modified flank position was given under general anesthesia. The umbilical area was aligned with the breaking point of the table, the table was positioned and with the aid of the kidney pad, flexion was made from this region. Pneumoperitoneum was created by entering the abdomen with a Veress needle (LapraSurge®, France), approximately 6-8cm lateral and 3-4cm superior to the umbilicus (meeting point with the anterior clavicular line and the lateral point of M. Rectus Abdominis) and creating a CO2 insufflation of 12mmHg. A 12mm trocar (Versaport®, Covidien Health Care, USA) was entered into the abdomen at the point previously entered with a Veress needle. After placing the camera, a second 12 mm study trocar was placed at approximately 2cm inferior of the intersection of the midclavicular line and the 12th costa, and a third 12 mm working trocar was placed

at the junction of the crista iliaca anterior superior and midclavicular line at the cranial direction of the umbilicus. In the right transperitoneal laparoscopic adrenalectomy cases, a 10mm 4th trocar was placed on the midclavicular line, 2cm inferolateral of the xyphoid, for use in the placement of a 10mm fan retractor (Endoretract®, Covidien Health Care, USA) for liver excision. 30 lenses (Hopkins®, Karl Storz, Germany) were used in all operations. Transperitoneal left laparoscopic adrenalectomy technique was first performed by sharp dissection, then Toldt ligament and the splenic flexura and descending colon were released and moved medially. The splenocholic and splenorenal ligaments were then cut using 5mm monopolar scissors (Endo Shears®, Covidien Health Care, U.S.A.) or 5 mm LigaSure (Covidien Health Care, USA). The suprarenal fossa was entered, first the left adrenal vein flowing into the left renal vein inferomedially to the adrenal gland, then the adrenal artery, was completely freed with the aid of a 5-mm laparoscopic nut (Autosuture®, Covidien Health Care, USA) and was clipsed with a metal clip (Weck Closure Systems; Research Triangle) and then was cut. The dissection was continued sharp and bluntly, primarily from the posterior of the adrenal gland and then from the neighboring kidney. After the adrenalectomy, specimen was taken out of the body with a 10cm bag (Endocatch, Covidien Health Care, USA).

In the transperitoneal laparoscopic right adrenalectomy, the right colon and duodenum were freed and medialized by entering the retroperitoneal area from the Toldt line. The triangular ligament of the liver was freed and moved to the superior area with the aid of a 10mm fan retractor (Endoretract®, Covidien Health Care, USA). The vena cava inferior (VCI) was revealed anatomically. The right adrenal vein, followed by the adrenal artery, was clipsed in the posterolateral side of the VCI, and cut by LigaSure. After the structure of the adrenal gland was defined, it was first released from the posterior, then from the neighboring kidney, by sharp and blunt dissection and taken out of the body with a 10cm specimen bag (Endocatch, Covidien Health Care, USA). A 10mm Jackson Pratt drain was placed at the surgical site in all operations.

Postoperative management

Patients who underwent bilateral surrenalectomy and was hemodynamically unstable, were followed up in the intensive care unit postoperatively. Patients with a cortisol releasing adenoma were treated on the first postoperative day with 3 doses of intravenous hydrocortisone (1-2mg/kg) at stress doses or prednisolone (25mg). After the first postoperative day, steroid replacement therapy was made with hydrocortisone or prednisolone tabled (a 10mg dose in the morning and a 5mg dose at night).

Statistical analysis

IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA) package program was used for statistical analysis of the data. Categorical measurements were summarized as numbers and percentages, and continuous measurements as means and standard deviations (median and minimum-maximum where necessary). Chi Fisher test statistics were used to compare categorical variables. In the comparison of continuous measurements between the groups, the distributions were controlled and Student T test was used for the parameters that normally distributed according to the number of variables. Statistical significance level was taken as 0.05 in all tests.

RESULTS

Our study included 81 patients. There were 22 patients in Group 1 conventional surgery (CS) and 59 patients in Group 2 Laparoscopic Surgery (LA). The mean age was 51.59 ± 13.12 in Group 1 and 48.05 ± 12.55 in Group 2(p=0.268). 50% of Group 1 and 52.5% of Group 2 consisted of female patients(p=0.518).BMI were 27.94 ± 5.37 in Group 1 and 27.48 ± 5.22 in Group 2(p=0.728).ASA score distributions were similar in both groups(p=0.529).42.4% of patients undergoing LA and 13.6% of patients who underwent CS were hormone-active and this difference was statistically significant(p=0.013). Tumor diameter was larger in patients treated with CS (CS: 6.58 ± 3.84cm; LA: 4.34 ± 1.77cm) (p=0.001) (Table 1).

The most common indications for surgery in the CS and LA groups were incidentaloma and metastatic masses, respectively(p=0.091). Other operation indications are shown in (Table 2). There was no difference between the localization of lesions in LA and left adrenal localization (63.6%) was more common in the CS group(p=0.229).The duration of the operation was calculated for CS and LA as 160 + 61.48 min and 108.81 + 29.55 min, respectively(p=0.001). The amount of intraoperative

bleeding was 152.27 + 107.43ml versus 51.27 + 51.57ml, it was higher in the CS group and was statistically significant(p=0.001). The initiation of oral intake and hospitalization time were significantly higher in patients treated with CS (p=0.001). No difference was found between postoperative complication rates (p=0.617). The most common complication was collection at the operation site and wound site infection. Two patients undergoing LA developed perioperative mortality. 1 patient died due to hemorrhagic shock and 1 patient died due to cardiac reasons. 3 (5.1%) patients were converted to conventional surgery because of difficulty in exploration in 2 patients and bleeding in 1 patient. Readmission rates within 90 days were similar between groups (p=0.297). Hypotension and pleural effusion in the CS, pancreatic fistula and wound infection in the area where the specimen was removed in LA were the most common causes (Table 3.)

Table 1. Demographic and clinical data

Parameter		**Open n (%)**	**Laparoscopic n (%)**	**p**
Age (min-max) ± sd		51.59±13.12 (27-71)	48.05±12.55 (19-70)	0.268
Sex	Male	11 (50.0)	28 (47.5)	0.518
	Female	11 (50.0)	31 (52.5)	
BMI (min-max) ± sd		27.94±5.37 (19-37)	27.48±5.22 (19-38)	0.728
Asa scoreo	1	12 (54.5)	40 (67.8)	0.529
	2	7 (31.8)	14 (23.7)	
	3-4	3 (13.6)	5 (8.5)	
Hormone activity		3 (13.6)	25 (42.4)	0.013
Tumor diameter (min-max) ± sd		6.58±3.84 (2-18)	4.34±1.77 (1-9)	0.001

Table 2. Operation indications

Parameter	**Open n (%)**	**Laparoscopic n (%)**	**p**
Incidentaloma	6 (27.3)	10 (16.9)	0.091
Carcinoma metastasis	6 (27.3)	12 (20.3)	
Pheochromocytoma	3 (13.6)	9 (15.3)	
Cyst	3 (13.6)	6 (10.2)	
Adrenocortical carcinoma	2 (9.1)	0 (0.0)	
Cortical hyperplasia	1 (4.51)	6 (10.2)	
Non-functional adenoma	1 (4.5)	4 (6.8)	
Conn syndrome	0 (0.0)	4 (6.8)	
Cushing	0 (0.0)	5 (8.5)	
Functional Adenoma	0 (00)	3 (5.1)	

Table 3. Intraoperative and Postoperative Characteristics

Parameter		**Open n (%)**	**Laparoscopic n (%)**	**p**
Localization	Left	14 (63.6)	27 (45.8)	0.229
	Right	8 (36.4)	28 (47.5)	
	Bilateral	0 (0.0)	4 (6.8)	
Operation duration, min (min-max)±sd		160±61.48 (100-300)	108.81±29.55 (60-240)	0.001
Intraoperative bleeding, ml (min-max)±sd		152.27±107.43 (50-400)	51.27±51.57 (0-400)	0.001
Starting oral intake (min-max)±sd		2.59±1.26 (1-5)	1.17±0.37 (1-2)	0.001
Hospitalization duration (min-max)±sd		6.14±4.31 (2-20)	3.42±2.64 (1-18)	0.001
Postoperative complications	Yes	2 (9.1)	5 (8.5)	0.617
Perioperative mortality	Yes	0 (0.0)	2 (3.4)	0.528
90-day hospital readmission	Yes	2 (9.1)	2 (3.4)	0.297

DISCUSSION

Adrenal glands are difficult to reach and operate on due to their anatomical neighborhood. Over the years, many open surgical approaches have been applied. These approaches require a large incision that causes significant morbidity and postoperative pain. However, access to the glands was facilitated by laparoscopic adrenalectomy and the surgery became less invasive[10,18].

Lateral transperitoneal approach has been the preferred surgical method since it provides a good exploration and anatomic orientation. In addition, it provides advantages of abdominal cavity exploration and, if necessary, additional surgical interventions. With LA, significant advantages were obtained with regards to hospitalization duration, bleeding amount, postoperative pain, functional improvement and cosmetics, when compared to CS[12,18,19].

Contraindications for LA are comprised of suspicious or proven malignant mass, local advanced cancer or large tumor size. With new dissection and vascular sealing devices, LA can be used in large adrenal masses[20,21].

In the literature, the age range for LA and CS has been reported as 44-63 years and 43-65 years, respectively. BMI varies between 24.7-34.1kg/m2 in CS and 25.5-35.0kg/m2 in LA[13,19,22,23]. In our study, age, sex and BMI were consistent with the literature and no statistical difference was found between the groups. In the study of Elfenbein et al., 68% of the patients who were administered CS and 60% of those who were treated with LA were ASA 3 patients($p<0.0001$).The CS approach was preferred in patients with a high ASA score[13]. In our study, while ASA scores showed similar characteristics in both groups, the number of patients with 1-2 ASA scores were significantly higher than the ASA 3 in the LA group($p=0.529$).The number of hormone-active masses was higher in LA patients($p=0.013$).Consistent with the literature, no difference was found between groups in terms of tumor localization($p=0.229$)[19,24]. It has been reported that bilateral adrenalectomy can be performed safely with a laparoscopic approach[25]. We performed bilateral LA safely in 4 patients. Our indications were carcinoma metastasis, pheochromocytoma and Cushing syndrome.

Malignancy rate is higher in large adrenal masses. Most of the older researchers do not recommend laparoscopic surgery, because the incidence of peripheral tissue invasion in these tumors, the risk of perforation of the tumor, which may lead to local recurrence or implants in the trocar regions. In recent studies, it has been reported that the surgical approach will not affect oncologic outcomes in adrenocortical carcinoma. In the literature, comparing to LA and CS, R0 resection rates, general and local recurrence rates, disease-free survival and mean survival times were similar in local or locally advanced primary adrenocortical carcinoma. LA seems to be equivalent to CS[26,27].

Sturgeon et al. reported that the incidence of malignancy will increase as the diameter increases in adrenal lesions(<4 cm=5%, ≧ 4 cm=10%and≧8 cm=47%)[28].Humphrey et al. found high tumor size in patients undergoing open surgery (5 cm) compared to those undergoing laparoscopic surgery (3.9 cm)($p= 0.01$)[29].In our study, the mean tumor diameter was 6.58 cm in patients undergoing CS and 4.34 cm in patients undergoing LA($p=0.001$).We think that this difference is due to the fact that we prefer conventional surgery in patients with a large tumor diameter. Although isolated carcinoma metastasis did not affect our surgical approach, we preferred CS in patients with primary adrenocortical carcinoma. In patients with isolated carcinoma metastasis, patient selection for LA is important. In preoperative evaluation, open surgery should be preferred in the presence of adjacent organ or periadrenal tissue invasion, lymphadenopathy, tumor greater than 10 cm, and presence of thrombus in renal vein or inferior vena cava[30].

Adrenal cystic lesions are reported as 0.064% and 0.18% in autopsy series. In various papers, 5.4% of adrenal masses were reported to be cystic. Surgical resection for adrenal cystic lesions should be performed if the hormone is active, at least 1 cm expansion of size per year, bleeding and calcification are detected in radiological evaluation[31,32]. In our study, surgery was performed on a total of 9 adrenal cystic lesions. Three patients were operated on with a conventional approach and 6 patients underwent the laparoscopic approach.

Surgical resection is the basis of both benign and malignant pheochromocytoma treatment. There was no difference in pheochromocytoma when hemodynamic instability and catecholamine levels were compared between laparoscopic and open surgery[33]. Pheochromocytoma is a hypervascular tumor. Hemostasis may be difficult laparoscopically

if intraoperative bleeding is accompanied by a hypertensive crisis during surgery. In addition, pheochromocytoma shows strong adhesions to surrounding tissues with a desmoplastic reaction[20]. While current guidelines of the National Comprehensive Cancer Network (NCCN) recommend open surgery in tumors with a high risk of malignancy; laparoscopic surgery should be the preferred method since it is safe and applicable[34]. The Endocrine Society 2014 guide proposes an open surgical approach to tumors larger than 6 cm or invasive pheochromocytomas, to provide complete resection, to prevent tumor rupture and ultimately local recurrence[35]. In our study, pheochromocytoma rates were similar in groups. Recommendations of the guidelines were taken into consideration in the selection of the surgical approach.

Conversion to open surgery in LA is reported to be between 0% and 23%[36-41]. The most common cause is bleeding from small venous structures. Other causes include vena cava or renal vein injuries, local or vascular invasion due to malignancy, abdominal adhesions, adjacent organ injuries, diaphragmatic injury, obesity, large liver, and large size of the mass[13].Our rate of conversion to open surgery was 5.1%. The most common causes were bleeding and exploration difficulty.

In general, the duration of LA has been reported as slightly longer than CS[10,23,28,42]. However, laparoscopic surgery can be performed in a shorter time with the completion of the learning curve[22]. In recent years, there has been an increasing number of publications indicating that they have completed LA in a much shorter time than open adrenalectomy. Elfenbein et al. reported an operative time of 160 minutes in CS and 130 min in LA in a 3100-disease series ($p<0.0001$)[13]. This is explained by the fact that 1- Open adrenalectomy is applied to large or invasive malignant tumors that require complex surgery, and 2-Increased laparoscopic surgical experience[43]. Our mean operation time was 108 minutes in the LA group and 160 minutes in the CS group. The difference between the two groups was statistically significant.

Another advantage of laparoscopic surgery is that the amount of intraoperative bleeding is less than that of open adrenalectomy. In the literature, it is stated that the amount of bleeding in open adrenalectomy is too high and this could be due to the fact that this surgery is mostly performed for large and invasive malignant tumors[19]. Chotirosnramit et al. reported 50 ml of intraoperative mean bleeding amount in the laparoscopic approach and mean 150 ml in the open approach ($p<0.001$).Many studies have reported that the amount of bleeding is less in the laparoscopic approach[12,19,29,44,45]In our cases, the amount of bleeding was significantly lower in the laparoscopic approach, as reported in the literature($p<0.0001$).

Early initiation of oral food intake and shortened hospitalization time are other advantages of LA. Bulus et al. reported an average of 1.05 days in the laparoscopic approach and 2.42 days in the open approach, for the restarting of oral food intake ($p = 0.001$, $p<0,005$)[10]. Lee et al. Found that the length of hospitalization was shorter in LA (mean 4.1 days) compared to CS (mean 9.4 days) ($p<0.0001$)[8]. Elfenbein et al. also published similar results ($p<0.0001$)[13]. We also found that the duration of hospitalization and restart of oral food intake were shorter in the LA group, similarly to the literature.

The rate of surgical complications is 5-10% in laparoscopic adrenalectomy in experienced centers and this rate is higher in open adrenalectomies. In CS, wound site problems are expected to occur more frequently than minimally invasive approaches[10,13,19]. There was no difference between the groups in terms of postoperative complications. Complications in LA were atelectasis, pleural effusion and collection at the operation area. Laparoscopy-specific complications were not observed in any patient. Massive bleeding, pulmonary complications, sepsis and cardiopulmonary failure are the most common causes of mortality after LA[25]. In our series, perioperative mortality occurred in two patients. The causes were massive bleeding and cardiopulmonary complications.

Complications after discharge can be a reason for readmission. The frequency of recurrence varies depending on the surgical discipline and the size of the surgery. This rate is between 5% and 15% after abdominal surgery[41]. Beck et al. reported the readmission risk factors after adrenalectomy as high ASA score, diabetes, advanced age, primary adrenal cancer surgery, long operation time, operation type and postoperative complications[47]. In our series, readmission was 9.1% in the open approach and 3.4% in the laparoscopic approach and this was not statistically significant($p=0.297$,$p<0.05$).Reasons for readmission were hypotension and pleural effusion in the open surgical approach group, and pancreatic fistula and wound infection in the area where the specimen was removed in the laparoscopic approach

group.The limitations of our study were its' retrospective nature, limited number of patients and being conducted in a single center.

In conclusion, in our study, we have also determined the advantages of LA compared to CS, such as short operation time, short hospital stay, decreased bleeding and early start of oral food intake. For laparoscopic adrenalectomy, good knowledge of conventional adrenalectomy and good laparoscopic surgery experience are required[12,13,19,29]. Complications can be avoided in LA performed by people with these experiences and the advantages of minimally invasive surgery can be achieved. We believe that laparoscopic adrenalectomy is an effective and safe surgical method when performed by experienced surgeons.

Yazar Katkıları: Çalışma konsepti/Tasarımı: KD, UT; Veri toplama: AGÜ; Veri analizi ve yorumlama: KD, UT; Yazı taslağı: KD, UT; İçeriğin eleştirel incelenmesi: KD, OY, İCE, GS; Son onay ve sorumluluk: KD, UT, AGÜ, İCE, OY, GS; Teknik ve malzeme desteği: -; Süpervizyon: OY, GS; Fon sağlama (mevcut ise): yok.
Bilgilendirilmiş Onam: Katılımcılardan yazılı onam alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazarlar çıkar çatışması beyan etmemişlerdir.
Finansal Destek: Yazarlar finansal destek beyan etmemişlerdir.

Author Contributions: Concept/Design : KD, UT; Data acquisition: AGÜ; Data analysis and interpretation: KD, UT; Drafting manuscript: KD, UT; Critical revision of manuscript: KD, OY, İCE, GS; Final approval and accountability: KD, UT, AGÜ, İCE, OY, GS; Technical or material support: -; Supervision: OY, GS; Securing funding (if available): n/a.
Informed Consent: Written consent was obtained from the participants.
Peer-review: Externally peer-reviewed.
Conflict of Interest: Authors declared no conflict of interest.
Financial Disclosure: Authors declared no financial support

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