Robot-assisted Laparoscopic Adrenalectomy: Step-by-Step Technique and Comparative Outcomes

Luis Felipe Brandao, Riccardo Autorino, Homayoun Zargar, Jayram Krishnan, Humberto Laydner, Oktay Akca, Maria Carmen Mir, Dinesh Samarasekera, Robert Stein, Jihad Kaouk *

Glickman Urological and Kidney Institute, Cleveland Clinic, Cleveland, OH, USA

Abstract

Background: Recent evidence supports the use of robotic surgery for the minimally invasive surgical management of adrenal masses.

Objective: To describe a contemporary step-by-step technique of robotic adrenalectomy (RA), to provide tips and tricks to help ensure a safe and effective implementation of the procedure, and to compare its outcomes with those of laparoscopic adrenalectomy (LA).

Design, setting, and participants: We retrospectively reviewed the medical charts of consecutive patients who underwent RA performed by a single surgeon between April 2010 and October 2013. LA cases performed by the same surgeon between January 2004 and May 2010 were considered the control group.

Surgical procedure: The main steps of our current surgical technique for RA are described in this video tutorial: patient positioning, port placement, and robot docking; exposure of the adrenal gland; identification and control of the adrenal vein; circumferential dissection of the adrenal gland; and specimen retrieval and closure.

Outcome measurements and statistical analysis: Demographic parameters and main surgical outcomes were assessed.

Results and limitations: A total of 76 cases (RA: 30; LA: 46) were included in the analysis. Median tumor size on computed tomography (CT) was significantly larger in the LA group (3 cm [interquartile range (IQR): 3] vs 4 cm [IQR: 3]; \( p = 0.002 \)). A significantly lower median estimated blood loss was recorded for the robotic group (50 ml [IQR: 50] vs 100 ml [IQR: 288]; \( p = 0.02 \)). The RA group presented five minor complications (16.7%) and one major (Clavien 3b) complication (3.3%), whereas four minor complications (8.7%) and one major (Clavien 3b) complication (2.3%) were observed in the LA group. No significant difference was noted between groups in terms of malignant histology (\( p = 0.66 \)) and positive margin rate (\( p = 0.60 \)). Distribution of pheochromocytomas in the LA group was significantly higher than in the RA group (43.5% vs 16.7%; \( p = 0.02 \)).

Conclusions: The standardization of each surgical step optimizes the RA procedure. The robotic approach can be applied for a wide range of adrenal indications, recapitulating the safety and effectiveness of open surgery and potentially improving the outcomes of standard laparoscopy.

Patient summary: In this report we detail our surgical technique for robotic removal of adrenal masses. This procedure has been standardized and can be offered to patients, with excellent outcomes.

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1. Introduction

To date, robotic surgery in urology remains mainly used for extirpative procedures including significant reconstructive components such as radical prostatectomy and partial nephrectomy, whereas its use for purely extirpative procedures such as nephrectomy and adrenalectomy is more limited mainly because of cost issues [1].

Since the report of initial cases in 2002 [2], da Vinci robot-assisted laparoscopic adrenalectomy (RA) has been shown to be safe and feasible [3]. Recent evidence supports the use of robotic surgery for minimally invasive surgical management of adrenal masses and suggests that RA can be effectively performed with operative time and complication rates similar to laparoscopy, but with potential shorter hospital stay and less blood loss [4].

The aim of the study is to describe a contemporary step-by-step technique of RA, to provide tips and tricks to help ensure a safe and effective implementation of the procedure, and to compare its outcomes with those of laparoscopic adrenalectomy (LA) in the experience of a single surgeon at a high-volume center.

2. Methods and patients

2.1. Study design

We retrospectively reviewed the medical charts of consecutive patients who underwent transperitoneal RA performed by a single surgeon (J.K.) in our center between April 2010 and October 2013. Data were acquired from our institutional review board–approved prospectively maintained database.

Transperitoneal LA cases performed by the same surgeon between January 2004 and May 2010 were considered as the control group. The two groups were compared in terms of surgical indications and perioperative outcomes.

2.2. Preoperative assessment and surgical indication

Indications for RA parallel those for LA including hormone-secreting tumors (ie, aldosteronomas, glucocorticoid, androgen- and estrogen-producing adenomas), solitary small pheochromocytomas, hormone-inactive lesions >3 cm demonstrating growth over time on serial imaging studies or >5 cm without observation, and rare lesions such as myelolipomas.

Special indications are the removal of malignant tumors or metastases. Increasing size and the suspicion of malignancy increase the difficulty of the procedure. Contraindications include infiltrative adrenal masses, involvement of large vascular structures or significant involvement of adjacent organs, and large tumors. General contraindications include serious cardiac conditions, severe cardiac insufficiency, and uncorrected coagulopathy.

In general, a multidisciplinary management plan involving an endocrinologist is followed in a patient presenting with an adrenal mass. The adrenal gland is evaluated with a computed tomography (CT) or magnetic resonance imaging to assess the location, size, and functional characteristics of the mass. Metabolic parameters (serum levels of aldosterone, cortisol, and catecholamines, as well as urine levels of metanephrines) are assessed to identify functional masses.

In cases of pheochromocytoma, patients are prescribed a preoperative 2-wk course of oral adrenergic blockade. Blood pressure is carefully monitored intraoperatively to ensure hemodynamic stability during the procedure and specifically during tumor manipulation.

2.3. Surgical technique

A detailed illustration of the surgical technique for RA can be found in the accompanying video material.

2.3.1. Robotic instrumentation

The da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) is used in a three-arm configuration, and the following robotic instruments are used: 30° down scope, ProGrasp forceps, Hot Shears (monopolar curved scissors), and a robotic clip applier. A monopolar cautery hook and Harmonic ACE curved shears (Ethicon Endo-Surgery Inc., CA, USA) can be also used when deemed helpful by the surgeon. We do not routinely use a bipolar energy source.

Laparoscopic instruments are handled by the bedside assistant including a Weck Hem-o-Lok clip applier (Teleflex Medical) and a suction device.

2.3.2. Patient positioning, port placement, and robot docking

The patient is placed in a 60° flank position. Extreme care is taken with pressure points and correctly padding them with pillows and foams. Tapes are used to secure the patient to the surgical table, which is mildly flexed and positioned in a slight Trendelenburg position. The patient’s arms are in a comfortable position, either both over a double arm board or one placed along the side of the body.

Similar to laparoscopy, precise port placement is essential to maximize exposure and ease of surgery. Right- and left-side port configurations are shown in Figure 1. After creating pneumoperitoneum using a Veress needle, a 12-mm port is inserted above and lateral to the umbilicus, at the lateral border of the abdominal rectus muscle across from the 12th rib. Through this first port, the robotic scope is inserted and the abdomen is carefully inspected to rule out any accidental injuries. Then the remaining ports are placed under vision including an 8-mm robotic port at the lateral border of the ipsilateral rectus muscle about 1 in below the costal margin, a second 8-mm robot port about 2 in cephalad to the anterosuperior iliac spine, and a 12-mm assistant port along the lateral border of the rectus muscle, halfway

(a)

(b)

Fig. 1 – Port configuration for (a) right and (b) left robot-assisted laparoscopic adrenalectomy.
between the camera port and the lower robotic port. For the right-side cases, an additional 5-mm port is placed below the xiphoid process in the midline, to help retract the liver by using an Allis locking clamp.

To avoid clashing between the robotic arms, the ports must be appropriately spread, about 8–10 cm distant from each other. In case of obese patients, ports need to be shifted laterally and cephalad to appropriately access the adrenal gland. This move is to avoid abdominal contents obstructing the view.

Similar to a robotic partial nephrectomy procedure [5], the robot is docked over the patient’s shoulder so its axis makes an obtuse angle in relation to the patient’s axis (Fig. 2).

2.3.3. Exposure of the adrenal gland
On the left side, complete medial bowel mobilization is needed to allow gland exposure. The lateral attachments of the spleen, as well as splenorenal ligaments, are divided. The spleen, bowel, and the pancreas are mobilized medially until the adrenal gland is clearly visualized. Attention must be paid to the tail of the pancreas because it can be mistaken for the adrenal gland.

On the right side, the triangular liver ligament is divided as cranially as possible to release the liver, and the locking grasper (placed through the subxyphoid trocar) is used as a liver retractor. The posterior peritoneum overlying the upper pole of the adrenal can also be incised to release the liver, which can then be retracted more superiority. After properly retracting the liver, the right adrenal can be accessed with minimal colon mobilization. For a better exposure of the inferior vena cava (IVC), the duodenum can be medially mobilized as well. If this is the case, the use of cautery needs to be minimized to avoid duodenal injuries.

2.3.4. Identification and control of the adrenal vein
On the left side (Fig. 3a and 3b), the renal hilum is identified, either by accessing it directly or after identifying and following the gonadal vein cephalically. It is necessary to identify and dissect the left renal vein because the adrenal vein is a tributary branch of it. Then the adrenal vein is carefully dissected and clipped by using the robotic clip applier, when available, or standard laparoscopic Hem-o-Lok clips placed by the bedside assistant.

On the right side (Fig. 4a and 4b), after the duodenum is kocherized, the lateral border of the IVC and the renal vein are identified. Dissecting cranially along the lateral border of the IVC, the right adrenal vein is encountered, dissected, clipped, and resected.

2.3.5. Circumferential dissection of the adrenal gland
Once the adrenal vein is properly controlled, the adrenal gland is circumferentially mobilized, beginning at the upper pole of the kidney, progressing to the medial surface of the diaphragm, and finding a plane between the posterior surface of the adrenal and the psoas muscle. Care must be taken during this step to control arterial blood supply (Fig. 5a and 5b), which can be done using clips or the Harmonic ACE. Layers of fat are left on the surface of the adrenal gland to use as a handle, thereby minimizing manipulation of the gland and avoiding fracturing it.

2.3.6. Specimen retrieval and closure
After checking the hemostasis by lowering the pneumoperitoneum, a laparoscopic entrapment sac is introduced by the assistant and the specimen is placed into the sac. After undocking the robot, the bagged specimen is extracted by extending the incision at the level of the assistant port. A Carter-Thomason device (Inlet Medical Inc., Eden Prairie, MN, USA) is used to close the 12-mm incisions. No drain is left in place.

2.4. Postoperative care and follow-up
Intravenous fluids, analgesics, antibiotics, and prophylaxis for deep vein thrombosis are given per institutional protocol. Hemoglobin levels and hematocrit are monitored. The patient is encouraged to ambulate gradually, and diet is advanced. The patient is discharged on the first or second postoperative day.
2.5. Data analysis

Collected demographics parameters were age, body mass index (BMI), gender, Charlson Comorbidity Index, American Society of Anesthesiologists (ASA) score, history of past abdominal surgery, and incidental diagnosis. Main surgical outcomes were assessed including operative time, estimated blood loss, length of hospital stay, transfusions and complications, total of morphine equivalents used, visual analog scale (VAS) score on the first postoperative day and on discharge, and 30-d readmissions. Postoperative complications were graded using the Clavien-Dindo system. Pathology findings were analyzed including pathologic tumor size, type of histology, and margin status.

Continuous variables were described as median and interquartile range (IQR), and the categorical variables were reported as count (percentage). Comparable analyses were performed using the Student t test for parametric continuous variables; the Mann-Whitney U test was used for nonparametric continuous variables. Chi-square tests were used to compare categorical parameters. The Fisher exact test was performed when required. Statistical significance was considered at p < 0.05.

3. Results

3.1. Demographics

Overall, 85 patients were identified. Nine LA patients were excluded because a retroperitoneal approach had been used. Thus 76 patients were ultimately included in the analysis (Table 1). There was no difference between groups in terms of age, BMI, gender, race, Charlson Comorbidity Index, history of past abdominal surgery, and tumor laterality. The RA group presented a significantly higher number of patients with an ASA score \( \geq 3 \) (80% vs 50%; \( p = 0.015 \)). However, the median tumor size on the CT was significantly larger in the LA group (3 cm [IQR: 3] vs 4 cm [IQR: 3]; \( p = 0.02 \)).

3.2. Perioperative outcomes

Table 2 presents a comparative analysis of the perioperative outcomes. No significant differences were noted in terms of operative times between the two groups, whereas significantly lower estimated blood loss was recorded for the robotic group (50 ml [IQR: 50] vs 100 ml [IQR: 288]; \( p = 0.02 \)). Length of hospital stay and 30-d readmission rate were comparable between groups. Median follow-up time was significantly longer for the conventional laparoscopic group (46 mo [IQR: 53.7] vs 4.5 mo [IQR: 6.5]; \( p < 0.001 \)).

There was no significant difference in the use of morphine equivalents per day during hospitalization.
(p = 0.42), as well as in VAS pain score assessment on postoperative day 1 (p = 0.64) and on discharge (p = 0.78).

### 3.3. Complications and transfusion rates

There were no significant differences between groups in terms of intraoperative complication rate (p = 0.23), intraoperative transfusion rate (p = 0.64), postoperative complication rate (p = 0.32), and postoperative transfusion rate (p = 0.64).

The RA group presented five minor complications (16.7%) and one major (Clavien 3b) complication (3.3%), whereas four minor complications (8.7%) and one major (Clavien 3b) complication (2.3%) were observed in the LA group. Minor complications in the RA group encompassed one case of hyponatremia, an episode of nausea and vomiting, a postoperative bleed requiring blood transfusion, a wound infection, and an atrial fibrillation. The minor complications from the LA group were a wound infection, and an atrial fibrillation. The minor (Clavien 1–2) complication rate (2.3%) was observed in the LA group and 4 cm (IQR: 3) in the LA group (p = 0.02). There were no differences between groups in terms of malignant histology (p = 0.66) and positive surgical margin rate (p = 0.60).

The positive surgical margin in the LA group was diagnosed as a pheochromocytoma on final pathology. Overall, 66% of the robotic masses were adenomas, which was significantly higher when compared with the LA group (32.7%; p = 0.009). Nevertheless, the total amount of pheochromocytomas in the LA group was significantly higher than in the RA group (43.5% vs 16.7%; p = 0.02).

### 4. Discussion

Here we describe in a step-by-step fashion a standardized technique of transperitoneal RA by providing tips and tricks for a safe and effective implementation of this procedure.

As for any other robotic procedure, careful case selection is of utmost importance for RA, especially during a surgeon’s early experience. Indications include hormone-secreting tumors, adrenal masses >5 cm, smaller lesions suspicious for malignancy, and lesions increasing in size on serial imaging [3]. Contraindications include infiltrative adrenal masses and tumors of extremely large size because size of adrenal lesions correlates with the potential for adrenal carcinoma [6]. A known (or suspected) diagnosis of adrenocortical carcinoma is better managed with open surgery because there might be an increased risk of recurrence and death compared with laparoscopy [7]. However, authors have advocated the feasibility of RA for adrenocortical carcinoma [8].

In the present RA series, no adrenocortical carcinoma was treated, and most of the masses were adenomas (60%), with pheochromocytoma representing the second most
common indication (16.7%). The lack of tactile feedback can be of concern during dissection of pheochromocytoma because inappropriate tumor manipulation can lead to catecholamine release. Aliyev et al. recently reported a first study focusing on RA for pheochromocytoma with a comparison to the laparoscopic technique [9]. They found similar perioperative outcomes, although larger tumors were removed in the robotic group. Intraoperative hemo-
dynamic parameters were also similar between the two approaches. In our series, smaller tumor sizes were observed in the RA group (median: 3 vs 4 cm; \( p = 0.02 \)), likely reflecting more careful selection criteria adopted in the early robotic experience.

Morbidly obese patients have been considered at higher risk of complications when undergoing LA [10]. Aksoy et al. did not find any difference in perioperative outcomes between RA and LA in obese patients, suggesting that difficulties in maintaining exposure and dissection in obese patients nullify the advantages of robotic articulating versus rigid laparoscopic instruments in adrenal surgery [11]. Notably, our RA population included obese and morbidly obese patients with a high median BMI of 29.5 kg/m\(^2\), which reflects the referral pattern for our tertiary care institution.

In laparoscopy, both the transperitoneal and retroper-
toneal approach can be used effectively [12]. According to a recent meta-analysis, the transperitoneal approach is the preferred one for RA [4]. The larger operative field of this approach aids in a better orientation and visualization of familiar anatomic landmarks, which is particularly helpful during the early learning curve. A larger working space is useful for removal of larger adrenal masses. For RA, other approaches to the adrenal gland also exist. Retroperitoneoscopy for RA was first described by Ludwig et al. [13]. This approach offers direct access to the adrenal gland without the need for visceral mobilization or lysis of adhesions from prior abdominal operations and the ability to perform bilateral adrenalectomy without repositioning the patient [14].

As for laparoscopy, trocar configuration remains a key factor in the operative setup for RA. In this study we describe a port configuration similar to that we routinely use for any robotic upper urinary tract surgery (ie, partial nephrectomy, nephrectomy, or pyeloplasty) [5]. This is based on the rationale of offering an effective and practical disposition of the trocars in the setting of a teaching hospital, where different residents and fellows are involved in the case. Since the initial cases done at our institution in 2002 [2], we have modified the port setup so the upper robotic port, the camera port, and the assistant port are along the same line, but instead of this line being from the umbilicus to the costal margin, it now corresponds to the lateral edge of the ipsilateral abdominal rectus muscle.

Berber et al. suggested placing the first optical 12-mm trocar midway between the umbilicus and the costal margin, and two 8-mm robotic trocars 2 fingerbreadths beneath the costal margin, and one 15-mm port for the assistant, which is the most medial port for right-side adrenalectomy and the most lateral port for left-side procedures [15]. A similar configuration was suggested by Brunaud et al. [16]. Krane et al. detailed their technique for right-side RA and suggested placing the patient in the full flank position, with 15° flexion of the table and using a 12-mm camera port placed 5 cm below the costal margin, midway between the midclavicular and anterior axillary line, and two 8-mm robotic ports placed to form an isosceles triangle pointing toward the right adrenal, each about 8 cm from the camera port. They also used an additional 8-mm robotic port placed below the xyphoid to use the fourth robotic arm and a 12-mm periumbilical port for the assistant [17]. A four-arm approach was also described by Giulianotti et al. [18], who placed the optical camera on the lateral side of the pararectal line above the umbilical transverse line and three robotic ports along a concave line focusing on the adrenal fossa plus a 12-mm assistant port placed near the umbilicus. In general, in our experience, similar to robotic partial nephrectomy [5], there is no need to use the third robotic arm, which translates into a cost reduction.

Based on the same rationale, we minimize the number of robotic instruments, so that we routinely use only a ProGrasp forceps and monopolar Hot Shears for the dissection of the adrenal gland as well as controlling the vessels. Only if strictly needed, we selectively use other tools such as the robotic clip applier, the monopolar cautery hook, and Harmonic ACE curved shears. Others advocated routine use of the Harmonic scalpel [19]. Taskin and Berber suggested the use of the Harmonic energy also for the division of the adrenal vein when <4 mm [15]. An alternative way of controlling the vein is the use of a robotic clip applier, which—thanks to the EndoWrist technology—allows the console surgeon to achieve the best working angle whenever the access is challenging for the bedside assistant.

Identification of vascular structures represents the most crucial and technically demanding step during adrenal surgery. The dissection of the adrenal vein can be challenging because of the unique anatomic location of the adrenal gland. Understanding variant adrenal venous anatomy is important to avoid bleeding, particularly in patients with large tumors or pheochromocytomas [20]. In this regard, extra attention to the venous anatomy is advised during right adrenalectomy. The left adrenal vein is easier to divide because it is longer and narrower; conversely, the right adrenal vein is easier to identify but shorter and more difficult to control. Adrenal arteries tend to be small and indistinct, and they usually can be easily cauterized [21].

Recognizing the main anatomic landmarks during both right- and left-side procedures is the best way to prevent inadvertent intraoperative complications. On the left side, the left renal vein, the tail of the pancreas, the superior pole of the kidney, and the psoas muscle can be very helpful to have a better exposure of the surgical field. On the right side, it is important to visualize the edge of the IVC, the right renal vein in addition with the superior pole of the kidney, and, not less important, the psoas muscle. During our adrenal dissection, the psoas muscle can be seen when mobilizing the gland circumferentially.
Regarding the surgical outcomes of RA, we observed a low intraoperative complication rate (3.3%), which is in line with other reported robotic series [22] and comparable with LA [4]. The only statistical difference between RA and LA in the present analysis was the blood loss, although it was of limited clinical significance ($\Delta = 50$ ml). We did not observe any difference in terms of length of hospital stay, as reported by Brunaud et al. [23] and confirmed by a recent meta-analysis reported by our own group [4].

The learning curve represents an intriguing issue when approaching a newly introduced surgical procedure. A widely used surrogate parameter as a measure of the learning curve is the operative time. Brunaud et al. observed in their series of 50 RA procedures that “operative time was reduced from 116 minutes for the first 20 patients to 87 minutes for the most recent RA group of patients ($p < 0.0003$)” [23]. When performing the same kind of analysis in our study population, we found that the last 20 RA cases presented better mean (standard deviation [SD]) operative time ($131 \pm 31$ min vs $150 \pm 104$ min; $p = 0.62$), less mean (SD) estimated blood loss ($87 \pm 87$ ml vs $312 \pm 771$; $p = 0.96$), and shorter mean (SD) hospital stay ($2.6 \pm 1.2$ d vs $2.2 \pm 1$ d; $p = 0.36$); nevertheless, none of the differences was significant. This might be related to the limited sample size itself and by the fact that the console surgeon had extensive previous experience with other robotic surgical procedures including upper urinary tract and pelvic surgery.

This study was intended to focus on our surgical technique for RA and to report comparative outcomes with LA performed by the same surgeon. In general, our results are consistent with the studies available in the recent literature and in line with a recent systematic review and meta-analysis suggesting that RA could result in a lower blood loss [4]. The small sample size and the retrospective design of the study might be regarded as the limitations of the study. It was outside our scope to provide a formal cost analysis. Few studies have attempted to assess the cost of RA compared with the laparoscopic or open approach. Brunaud et al. estimated RA to be 2.3 times more costly than LA [23]. Winter et al. compared median operative charges and overall hospital charges for robotic, laparoscopic, and open adrenalectomy. Although they found that operative charges were over twice as much for robotic versus open adrenalectomy, median hospital charges were $1600 more for open adrenalectomy than for RA or LA because of shorter hospitalizations for patients who underwent minimally invasive surgery [22]. Contemporary prospective randomized studies are needed to compare LA and RA conclusively. As robotic systems become more widely used and the volume of robotic surgery increases, maintenance, preparation, and cost issues will become less burdensome, and the role of robotics in adrenal surgery will be clarified.

5. Conclusions

Our contemporary technique for RA is detailed in this study. The standardization of each surgical step, based on the recognition of main anatomic landmarks and the knowledge of potential intraoperative complications, allow an optimization of this procedure. The robotic approach can be safely and effectively applied for a wide range of adrenal indications, potentially improving the outcomes of the standard laparoscopic approach.

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Study concept and design: Brandao, Autorino, Kaouk.

Acquisition of data: Brandao, Laydner, Akca, Mir.

Analysis and interpretation of data: Brandao, Autorino, Zargar.

Drafting of the manuscript: Brandao, Autorino.

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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at http://dx.doi.org/10.1016/j.eururo.2014.04.003 and via www.europeanurology.com.

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