JOURNAL OF LAPAROENDOSCOPIC & ADVANCED SURGICAL TECHNIQUES
Volume 31, Number 4, 2021
Mary Ann Liebert, Inc.
DOI: 10.1089/lap.2020.0839

Robotic Versus Laparoscopic Adrenalectomy: Pluriannual Experience in a High-Volume Center Evaluating Indications and Results

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Abstract

Background: Robotic adrenalectomy offers several clinical benefits if compared with laparoscopic adrenalectomy; however, its superiority is still under debate. The aim of this study was the investigation of differences between the two techniques, and a comparison when approaching right or left side adrenal lesions was further conducted.
Materials and Methods: All patients undergoing laparoscopic and robotic unilateral adrenalectomy at our institution from January 2006 to December 2019 were collected and retrospectively analyzed. Statistical analysis was conducted; differences between the two cohorts were reported.
Results: A total of 160 cases were included (84 patients in laparoscopic adrenalectomy-group [LA-g] 76 cases in robotic adrenalectomy-group [RA-g]). The groups were homogeneous for demographic data. No intraoperative complications were reported; mean amount of intraoperative blood loss was comparable. No cases of conversion to open surgery were required. RA-g presented a longer operative time than LA-g for right adrenalectomy ($P = .05$), no differences were noted for left side ($P = .187$). Overall morbidity was 21% for LA-g and 10.5% for RA-g ($P = .087$), with an inferior rate of surgical complications for RA-g ($P = .024$), and for robotic left adrenalectomy than robotic right procedure ($P = .03$). Length of hospital stay was shorter for RA-g ($P = .005$).
Conclusions: Robotic adrenalectomy presents similar outcomes as laparoscopic approach with some benefits for selected cases. Left adrenal lesions seem to receive greater advantages from robotic technique. Large randomized controlled trials are required to determine the role of robotic adrenal surgery and if the indication can be standardized based on the laterality of adrenal procedure.

Keywords: adrenalectomy, adrenal gland surgery, robotic adrenalectomy, laparoscopic adrenalectomy, robotic surgery

Introduction

In recent years, mini-invasive robot-assisted adrenalectomy was introduced as an alternative technique to conventional laparoscopic approach to overcome some drawbacks of laparoscopic surgery.[1,2] Authors consider adrenal surgery a technically demanding procedure requiring meticulous dissection in a relatively limited space dealing with major vessels and organs in an adrenal cortical-sparing optic[3,4]; thus, many surgeons, thanks to the stereoscopic vision, improved magnification and greater range of motion within a limited working space, find in the robotic platform a beneficial alternative to conventional laparoscopic approach.[4–6] Nevertheless, laparoscopic adrenalectomy (LA) still remains the gold standard procedure,[2] no clear improvements from the use of the robotic platform have been validated in

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comparative studies and large series evaluating clinical outcomes after robotic adrenalectomy are currently not available.[4,7] In particular, the debate is still open concerning specific parameters, such as body mass index (BMI), size of the lesion and laterality of adrenal gland, and standard indications of robot application to adrenal surgery are still lacking.[5,7,8] We present in this study the experience in mini-invasive surgical treatment of adrenal glands at our Institution, where in past years robotic adrenalectomy has progressively juxtaposed to laparoscopic technique. Purpose of our study was to compare outcomes of the two surgical approaches, mainly investigating specific variables, such as BMI and tumor size, to rule out if and when robot-assisted approach can be preferable to conventional laparoscopy. The second endpoint was to compare outcomes of right- versus left-sided adrenal lesions for both the techniques. To the best of our knowledge this is the largest series of adrenal procedures comparing laparoscopic and robotic approach at a single institution, and for the first time a comparison for laterality is described.

Materials and Methods

Patients

A retrospective observational study of adrenal surgical procedures performed at our institution between January 2006 and December 2019 was conducted. All consecutive patients older than 18 years who underwent mini-invasive, laparoscopic and robotic, adrenal surgery for benign and malignant lesions were included; open and bilateral adrenalectomies represented exclusion criteria. The Da Vinci Si robotic system (Intuitive Surgical, Inc., Sunnyvale, CA) was applied. All included patients were operated by one senior surgeon with an established experience in mini-invasive and adrenal surgery. Data were inserted into a database utilizing medical records. The study was conducted in accordance with the Declaration of Helsinki.

All cases were preliminarily discussed in multidisciplinary board and indication to surgery was defined in accordance between surgeons and endocrinologists. The perioperative management included admission of patients the day before surgery, subcutaneously antithrombotic prophylaxis 12 hours before intervention and intravenous specific antibiotic prophylaxis were administered.

Data collection

For all patients, the following data were collected: age, gender, BMI, comorbidities, American Society of Anesthesiologists (ASA) score, perioperative details, characteristics of adrenal lesion, surgical procedure data and postoperative outcomes, and length of hospital stay (LOS). Surgical complications were stratified according to Clavien–Dindo classification.[9] Total operative time (OT) was defined as duration in minutes from skin incision to port-site closure; in case of additional open resections associated to robotic-assisted phase, OT was considered from skin incision to the undocking time. For robotic procedures, total time data included different phases: the docking, the console time, and the undocking. Blood loss was considered as the amount of volume (mL) from drainage.

A comparative analysis between the laparoscopic and robotic technique was conducted. In particular, results in terms of OT for the two approaches were analyzed in consideration of specific variables: laterality, BMI, and dimension of adrenal lesion with a cutoff between <6 and ≥6 cm. As we know, right- and left-side approaches present different anatomical fields and some different technical surgical aspects; thus, a further subdivision of the cohort into right- and left-side groups was performed and a comparison between the two surgical techniques was concluded.

Statistical analysis

All data were collected in an electronic database and the statistical analyses were performed using the Statistical Package for the Social Sciences' (SPSS) software for Windows (version 25.0; SPSS, Inc., Chicago, IL). For all comparisons, $P < .05$ was considered statistically significant. Continuous variables were reported as median values; the nonparametric Mann–Whitney U test followed by the Dunn's multiple comparison *post hoc* test were used for comparisons of continuous variables resulted not normally distributed at the Kolmogorov–Smirnov test. Categorical variables were reported as frequencies and percentages and they were compared by the chi-square test. Pearson' correlation was used for continuous variables. Linear regression analysis was used to examine the association between continuous variables; results were expressed through β and R^2 coefficients. Bivariate logistic regression was used for categorical variables.[10]

Results

A total of 172 patients were collected; among these, open and bilateral procedures were excluded ($n = 12$), whereas 160 patients received mini-invasive adrenalectomy, including 84 cases of LA (laparoscopic adrenalectomy-group [LA-g]) and 76 cases of robot-assisted procedures (robotic adrenalectomy-group, RA-g). The two groups resulted homogeneous for gender, age, BMI, ASA score, and laterality of presented adrenal lesion; all patients' demographic and clinical characteristics are resumed in Table 1. Indications to laparoscopic or robotic surgery were similar for all patients and followed international recommendations.[2] Diagnosis was obtained in consideration of clinical symptoms, laboratory examinations and radiological imaging. Twenty-eight cases in LA-g and 20 cases in RA-g were occasional findings at radiological imaging performed for other reasons.

Imaging studies always included computed tomography scan; magnetic resonance imaging, positron emission tomography, and scintigraphy were performed according to diagnostic work-up when required. Mean size of adrenal lesion was 5.1 cm (range 1.2–16) for LA-g and 4.03 cm (range 0.5–15) for RA-g, $P = .019$; lesions ≥6 cm were registered in 17.5% and 15.8% of cases among LA-g and RA-g, respectively ($P = .010$).

Table 2 resumes all perioperative results. In LA-g, 6 cases of additional resections were performed during the same laparoscopic surgery (4 cholecystectomies and 2 defenestrations of hepatic cysts). In RA-g, two cholecystectomies were full-robotically performed in combination with adrenalectomy, whereas one additional ileal resection requiring a mini-laparotomy and one left open nephrectomy were, respectively, performed after robot-assisted phase concluded.

Table 1. Demographic Data and Clinical Characteristics

	Total cohort (n = *160*)		
	LA-g (n = *84*)	*RA-g* (n = *76*)	p
Gender			
Male	37 (44)	33 (43.4)	.936
Female	47 (56)	43 (56.6)	
Mean age, years (range)	57.9 (24–83)	57.2 (17–81)	.913
Mean BMI (range)	27 (15.6–45)	28.3 (19.7–42.1)	.185
BMI			
<30	67 (79.8)	67 (88.2)	.151
≥30	17 (20.2)	9 (11.8)	
ASA			
I	14 (16.6)	13 (17.1)	
II	50 (59.5)	53 (69.7)	.381
III	18 (21.4)	9 (11.8)	
IV	2 (2.3)	1 (1.3)	
Previous abdominal surgery	42 (50)	21 (27.6)	.004
Mean size, cm (range)	5.1 (1.2–16)	4.03 (0.5–15)	.019
≥6 cm	28 (17.5)	12 (15.8)	.010
Laterality			
Right side	41 (48.8)	37 (48.7)	.886
Left side	43 (51.2)	39 (51.3)	
Preoperative diagnosis			
Nonsecretive adenoma	18 (21.4)	16 (21)	
Cushing adenoma	13 (15.4)	12 (15.8)	
Conn adenoma	10 (11.9)	19 (25)	—
Pheocromocytoma	13 (15.5)	1 (1.3)	
Metastasis	14 (16.7)	5 (6.6)	
Cystic lesion	2 (2.4)	1 (1.3)	
Angiomyolipoma	5 (5.9)	5 (6.6)	
Carcinoma	5 (5.9)	3 (3.9)	
Hyperplasia	4 (4.8)	1 (1.3)	
Oncocytoma	—	1 (1.3)	

Data presented were *n* (%), unless specified.

ASA, American Society of Anesthesiologists; BMI, body mass index (kg/m^2); LA-g, laparoscopic adrenalectomy-group; RA-g, robotic adrenalectomy, group.

No intraoperative complications were reported for both groups and the mean amount of intraoperative blood loss was comparable between LA-g and RA-g (Table 2). No cases of conversion to open surgery were required. Laparoscopic approach required more frequently the placing of a drain (LA-g 97.6% versus RA-g 85.5%, $P = .005$). Further perioperative details are reported in Table 2. Overall mean OT in LA-g was significantly shorter than robotic one ($P = .040$). In all patients the duration of the surgical procedure was directly correlated to the dimension of the adrenal mass (ß = +0.20; $R^2 = 0.042$; $P = .01$).

The mean time to first flatus after surgery was 1.4 days (range 1–3) for LA-g and 1.1 days (range 1–2) for RA-g ($P = .110$). All patients started oral intake on first postoperative day. Abdominal drain was usually removed the day before patient's discharge. The overall rate of postoperative complications at 30 days did not differ between LA-g and RA-g, being of 21.4% and 10.5%, respectively ($P = .087$). Medical complications (i.e., pneumonia, pleural effusion, and urinary tract infection) were similar between the two groups (1.9% versus 9.2%, $P = .058$), whereas an inferior rate of surgical complications was registered for RA-g if compared with LA-g (1.3% versus 9.5%, $P = .024$). Postoperative complications were categorized according to Clavien–Dindo classification.[9] All postsurgical outcomes are reported in Table 2. One case of left ureteral injury was described and successfully managed by an ureteral stenting in laparoscopic group. Discharge criteria consisted in adequate pain control with oral medication, absence of nausea and or/vomiting, passage of flatus, nonelemental diet and soft food well-tolerated, mobilization, and self-support. In our series the mean LOS was calculated from the day of surgical operation to the day of discharge; LOS resulted shorter for RA-g than for LA-g ($P = .005$). No cases of readmission were reported, and mortality at 30 days was 0% for both groups. Definitive pathological findings are summarized in Table 2.

Analysis for laterality

According to our knowledge, this is the first series presenting a comparison between different surgical approaches (laparoscopic versus robot-assisted) where the laterality of adrenal gland was applied as further criteria of analysis (Table 3). Mean laparoscopic OT presented a tendency to be shorter than robotic one in right side, whereas no differences between laparoscopy and robot were noted at left side. Moreover, laparoscopic technique and robotic approach did not present differences when approaching right-side adrenal glands in terms of rates of intra- and postoperative complications, placement of abdominal drain and need to transfusions. On the contrary, among left-side group, robotic technique registered an inferior rate of both medical and surgical postoperative complications than laparoscopic technique. Length of hospital stay in both right and left adrenalectomy presented a trend in favor of robotic technique.

In consideration of laterality, a further analysis was performed to evaluate the relation between side of the adrenal lesion, BMI, and diameter of the mass in influencing the duration of surgical procedure for both laparoscopic and robotic techniques; all findings are reported in Table 4.

Discussion

In past decades, minimally invasive technique considerably increased its application in abdominal surgery. Particularly, adrenal surgery assisted to a progressive revolution in these terms, with the first LA performed in 1992 by Gagner et al.[11] and with the first application of robotic platform in 1999.[12,13] According to the last guidelines LA consolidates its strength of benefits compared with traditional open approach and it is validated as the gold standard technique with the lateral transabdominal approach to be preferred than the posterior one.[2] Recently, many authors advocated toward the safety and satisfactory outcomes of robotic adrenalectomy,[14] but today a consensus regarding the true benefit of robotic surgery over conventional laparoscopy in treating adrenal pathology remains still under debate.[4] Preliminary results are encouraging in favor of robotic platform, but issues dealing with procedural operating time and cost effects represent a

Table 2. Peri- and Postoperative Data

	Total cohort (n = *160*)		
	LA-g (n = *84*)	*RA-g* (n = *76*)	p
Perioperative complications	—	—	—
Conversion to open surgery	—	—	—
Mean estimated blood loss, mL (range)	110 (70–250)	90 (50–220)	.081
Additional resections	6 (7.1)	2 (2.6)	.897
Abdominal drain	82 (97.6)	65 (85.5)	.005
Mean operative time, minutes (range)	89.9 (38–230)	100.3 (40–265)	.040
Postoperative complications			
Medical	10 (1.9)	7 (9.2)	.580
Pneumonia (*n*)	4	2	
Pleural effusions (*n*)	3	4	.024
IVU (*n*)	3	1	
Atrial fibrillation (*n*)	1	—	.619
Surgical	8 (9.5)	1 (1.3)	
Hematoma/bleeding (*n*)	4	—	
Abdominal collection (*n*)	2	1	
Ureter injury (*n*)	1	—	
Ileus (*n*)	1	—	
Clavien–Dindo ≥3	1 (1.2)	—	
Reintervention	—	—	—
Blood transfusions	3 (3.6)	—	.210
Mean hospital stay, days (range)	4.07 (2–16)	3.2 (2–14)	.005
30-Days mortality	—	—	—
Pathological findings			
Cushing adenoma	12 (14.3)	9 (11.8)	
Conn adenoma	10 (11.9)	12 (15.8)	
Metastasis	14 (16.7)	5 (6.5)	
Cystic lymphangioma	2 (2.4)	3 (3.9)	
Carcinoma	5 (5.9)	1 (1.3)	
Myelolipoma	6 (7.1)	5 (6.5)	
Nonsecretive adenoma	19 (22.6)	24 (31.5)	—
Pheocromocytoma	14 (16.7)	14 (18.4)	
Hyperplasia	1 (1.2)	1 (1.3)	
Lymphoma	1 (1.2)	—	
Oncocytoma	—	1 (1.3)	
Primary pigmented nodular adrenocortical disease	—	1 (1.3)	

Data presented were *n* (%), unless specified.
LA-g, laparoscopic adrenalectomy group; RA-g, robotic adrenalectomy group.

remarkable barrier for the definitive overcome of robotic system over laparoscopic procedure.[4,8]

In our study, we report the pluriannual experience in mini-invasive surgery applied to adrenal pathologies at our institution, where a specialized endocrine surgeons team is involved. Our first laparoscopic lateral transabdominal adrenalectomy was performed in 2006, and a progressive consolidation of its application as the standard treatment was achieved. With the advent of robotic surgery, the Da Vinci Si system arrived at our institution in 2005 and since then robotic activity progressively gained success in endocrine, colorectal, and gastroesophageal activities. Our endocrine surgical team already reported excellent results in the field of transaxillary thyroid surgery[15]; the certainty of being able to count on mini-invasive surgical skills and clinical competence allows us today to present one of the largest series of adrenal gland surgery comparing laparoscopic and robot-assisted technique. Moreover, in 2011, robotic platform started to be applied more frequently at our center, until the proportion with laparoscopy inverted in 2013, registering a rapid increase of the learning curve.

In 2004, Brunaud et al. presented the first comparison between laparoscopic and robotic adrenalectomy,[16] whereas the only prospective randomized controlled clinical trial comparing the two techniques was published by Morino et al.[17]; these series were still small, reporting no more than 20 procedures and no clear benefits of robotic approach resulted as major criteria to overcome LA. Nevertheless, at present the international literature finds accordance in proposing the robotic platform for specific categories of patients, such as obese (BMI ≥30 kg/m^2), where the dissection in narrow spaces could result easier with robot than laparoscopically.[6,16,18] According to our experience, the BMI does not influence the selection of the surgical procedure; besides, our mean BMI represents one of the highest value among other robotic series reported in literature. These data not only show that high BMI does not represent a contraindication to robotic adrenalectomy, but that in expert hands obese patients can even benefit from the robotic dissection. However, other authors consider obesity an independent risk factor in adrenal surgery.[19,20]

According to OT, we registered mean values for laparoscopic adrenalectomies and for robotic procedures both

Table 3. Comparison Between Laparoscopic Adrenalectomy-Group and Robotic Adrenalectomy-Group According to Laterality

	Total cohort (n = *160*)					
	Right side (n = *78*)			*Left side* (n = *82*)		
	LA-g (n = *41*)	*RA-g* (n = *37*)	p	*LA-g* (n = *43*)	*RA-g* (n = *39*)	p
Gender						
Male	19 (46.3)	19 (51.3)	.658	18 (41.8)	14 (35.8)	.580
Female	22 (53.7)	18 (48.7)		25 (58.2)	25 (64.2)	
Mean age, years (range)	56.9 (27–77)	55.5 (19–81)	.872	58.9 (83–34)	58.3 (33–77)	.896
BMI						
<30	32 (78)	32 (86.4)	.332	35 (81.4)	35 (89.7)	.285
≥30	9 (22)	5 (13.6)		8 (18.6)	4 (10.3)	
Previous abdominal surgery	21 (51.2)	11 (29.7)	.054	21 (48.8)	10 (25.6)	.031
Abdominal drain	40 (97.5)	32 (86.4)	.067	42 (97.6)	33 (84.6)	.035
Mean operative time, minutes (range)	86.2 (38–175)	103.9 (45–265)	.058	93.4 (40–230)	99.6 (40–180)	.187
Postoperative complications	5 (12.1)	2 (5.4)	.335	13 (30.2)	6 (15.3)	.143
Medical	4 (9.7)	2 (5.4)	.495	6 (13.9)	5 (12.8)	.035
Surgical	1 (2.4)	0	.495	7 (16.2)	0	.036
Blood transfusions	1 (2.4)	0	.377	2 (4.6)	0	.185
Mean hospital stay, days (range)	3.9 (2–16)	3.2 (2–7)	.072	4.1 (2–14)	3.7 (2–14)	.204

Data presented were *n* (%), unless specified.
BMI, body mass index (kg/m^2); LA-g, laparoscopic adrenalectomy group; RA-g, robotic adrenalectomy group.

inferior to ones reported by other series currently present in scientific panorama.[4,20] This finding reflects how surgical experience plays a significant role in determining the overall duration of surgical operations. As expected, OT was shorter in LA-g than RA-g when comparing the two groups. A significantly longer OT is widely attributed to the use of the robot, accordingly to the robotic setup, the time needed to advance the robotic cart and connect the robotic arms to the trocars as well as the undocking phase, but we strongly believe that additional time may decreases as more robotic procedures are performed, with surgeons acquiring an increasing learning curve and progressively consolidating their skills. Notably, prior studies confirmed this concept, as Agcaoglu et al. who reported a significant improvement in OT after 10 robotic adrenal procedures,[21] and Brunaud et al. observing similar results between laparoscopic and robotic adrenalectomy after 20 robot-assisted procedures.[18]

Interesting is the lower rate of positioning an abdominal drain in favor of robotic group, reflecting the tendency of reduced risk of bleeding reported by robotic adrenalectomies[4,22] and the consequent fact that surgeons feel more confident.

Principal complications associated with mini-invasive adrenalectomy are hemorrhage, injuries of adjacent organs, wound infection, ileus, atelectasis, and pleural effusion. In terms of morbidity, no significant difference between RA-g and LA-g for both peri- and postoperative complications were reported by a recent metanalysis.[4] In our series, we found a better trend in favor of robotic procedures in terms of short-term postoperative surgical complications. This result seems to be very encouraging; Aksoy et al. reported a high complication rate in the robotic group of 4.8%,[5] and incidences reported in literature are also higher, ranging between 5% and 10%.[23,24] Furthermore, we found a significant shorter hospital stay among the robotic group compared with laparoscopic one, reflecting data by other authors.[5,23,25] The shorter hospital stay may allow also reducing costs of hospitalization and a higher turnover of patients in surgical units, thus balancing the principal drawback of robotic platform of higher costs.[6,8,26] Brunaud et al. calculated that

Table 4. Comparison of Operative Time (Minutes) Between Laparoscopic Adrenalectomy-Group and Robotic Adrenalectomy-Group According to Laterality, Body Mass Index, and Lesion Diameter

	OT for total cohort (n = *160*)					
	Right side (n = *78*)			*Left side* (n = *82*)		
	LA-g (n = *41*)	*RA-g* (n = *37*)	p	*LA-g* (n = *43*)	*RA-g* (n = *39*)	p
BMI <30	88.2 (40–175)	103.3 (50–265)	.443	96.4 (65–230)	99.1 (65–150)	.300
BMI ≥30	79 (55–116)	108 (90–135)	.028	80.3 (53–125)	104.2 (62–135)	.230
Lesion <6 cm	82.9 (38–175)	95.4 (45–210)	.103	88.5 (40–230)	99 (40–180)	.077
Lesion ≥6 cm	92.6 (40–152)	135 (50–265)	.110	103.6 (70–205)	105.5 (75–117)	.645

Data presented were mean values (minutes).
BMI, body mass index (kg/m^2); LA-g, laparoscopic adrenalectomy group; OT, operative time (minutes); RA-g, robotic adrenalectomy group.

robotic approach was 2.3 times more expensive than laparoscopic one,[6] but notably, costs could be curtailed by increasing the annual workload of robotic surgical procedures in high-volume centers,[4,26] leading also to a facilitation of the learning curve. From this cost-saving standpoint, the widespread adoption of robotic technology may conduct to a beneficial effect on robotic purchase, but published data at present are not sufficient yet and further studies are necessary.[26,27]

Nowadays, standard indications of robotic platform to adrenal surgery have not been validated yet; some authors have considered the presence of some factors, such as BMI >30 kg/m^2, tumor size >5 cm, and a previous history of abdominal surgery, as good indicators for robotic preference.[5,7,18] In our series, no cases of conversion to open surgery was registered notwithstanding adrenal lesions with a maximum diameter ≥6 cm were 17.5% and 15.8% in LA-g and RA-g, respectively, and a correlation with the diameter of lesion was found only with the length of surgical operation. However, we believe that capsular rupture represents an important risk when managing adrenal lesions, especially large lesions and pheocromocytoma; thus, these patients should be referred to expert centers where robotic approach may represent a helpful tool to ensure the most atraumatic and precise manipulation.

To the best of our knowledge, our study describes the first comparison between laparoscopic and robotic adrenalectomy according to the laterality of adrenal lesion. Our assumption arises from the idea that right and left adrenalectomy are considered as distinct interventions, interfacing with two different anatomical districts and requiring specific technical skills. In particular, if right adrenalectomy requires the control of the inferior vena cava, left adrenalectomy seems to be more challenging in case of mobilization of the left colic flexure and the risk of spleen and pancreatic injury.[7,16] We also believe that right adrenalectomy may represent the starting surgical step for surgeons facing to adrenal surgery for the first time. From this concept, therefore, the idea of developing a detailed comparative analysis between the two techniques for each of the two laterality. No other authors proposed this type of comparison previously.

In particular, for right adrenalectomy we found a shorter OT in laparoscopic group, but at left robotic and laparoscopic techniques resulted in similar procedural duration with no differences when considering BMI and lesion diameter. Furthermore, the major advantages of robotic technique were seen in left adrenalectomy with an inferior rate in positioning abdominal drainage and lower rates of postoperative morbidity. Robotic system seems to be superior for more complex and difficult cases, especially for large tumors, obese patients, and left-sided lesions. The correct interpretation of this stays in the well-known benefits offered by robotic platform that can strongly prove its effectiveness when applied to challenging anatomical fields dealing with deep anatomical structures and requiring maximal accuracy in dissection.

The strength of this study stays in the homogeneity between the laparoscopic and robotic groups, the large sample size, and the subanalysis for the laterality of the adrenal lesions. The study was conducted in a high-volume center with an established mini-invasive surgical experience and where all surgical indications were approved by a multidisciplinary board, leading to the possibility of a standardization of indications and technique. However, this study has some limitations. It is a monocentric study of a nonrandomized series of patients, based on a retrospective database, the sample is still small and mainly the first patients may have been selected and addressed to a specific technique by creating a bias on the conclusions. Further multicentric prospective randomized trials are necessary to confirm our findings for a larger number of surgeons in comparable high-volume centers.

Conclusions

Advantages of robotic adrenalectomy over the conventional laparoscopy are still matter of debate and robotic surgery cannot assume a well-defined role in treating adrenal pathology. According to our experience, the real superiority of robotic technique can be found when applied to more challenging cases, including large adrenal masses and obese patients. Furthermore, left adrenal lesions seem to receive greater benefits from robotic approach than right sided, with a minor rate of complications than laparoscopy but with similar OT. These findings suggest us a routinary application of robotic left adrenalectomy and only for right-sided selected cases, but, at present, large randomized controlled trials are required to extract safe and dependable answers on the potential benefit of robotic approach and to understand if the technique may be chosen based on the laterality of adrenal gland; our purpose remains to be validated in future studies.

Authors' Contribution

All authors are responsible for the article and have taken part in writing, reviewing, and revising the contents of the article.

Disclosure Statement

No competing financial interests exist.

Funding Information

No funding was received for this article.

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