ORIGINAL ARTICLE

Robotic vs Laparoscopic Posterior Retroperitoneal Adrenalectomy

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Objective: To compare robotic vs laparoscopic posterior retroperitoneal adrenalectomy with regard to perioperative outcomes.

Design: Prospectively study.

Setting: Tertiary academic center.

Patients: Thirty-one patients who underwent robotic posterior retroperitoneal adrenalectomy and 31 consecutive patients who underwent laparoscopic posterior retroperitoneal adrenalectomy from a prospective institutional review board–approved database.

Main Outcome Measures: Demographic and clinical parameters, operative time, presence of complications, length of hospital stay, and pain score on postoperative days 1 and 14.

Results: The mean (SEM) tumor sizes for the robotic and laparoscopic groups were similar (3.1 [0.2] and 3.0 [0.2] cm, respectively; $P = .48$). For all patients, the mean (SEM) skin-to-skin operative times were similar in both groups (163.2 [10.1] and 165.7 [9.5] minutes, respectively; $P = .43$). When the last 21 patients who underwent robotic posterior retroperitoneal adrenalectomy were compared with the 31 patients from the laparoscopic series, it was seen that the mean (SEM) operative time was shorter for the robotic group than for the laparoscopic group (139.1 [10.9] vs 166.9 [8.2] minutes; $P = .046$). The mean (SEM) estimated blood losses and hospital stays were similar between groups. The mean (SEM) pain score on postoperative day 1 was lower in the robotic group than in the laparoscopic group (2.5 [0.3] vs 4.2 [0.4]; $P = .008$); however, the mean (SEM) pain scores for the groups were similar on postoperative day 14 ($P = .53$). There were no deaths or cases of morbidity in either group.

Conclusions: Our study shows that, beyond the learning curve for experienced laparoscopic surgeons, robotic posterior retroperitoneal adrenalectomy shortens the skin-to-skin operative time compared with the laparoscopic approach. Our results also suggest that the immediate postoperative pain may be less severe for patients who undergo robotic posterior retroperitoneal adrenalectomy.

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ROBOTIC ADRENALECTOMY was initially described through the lateral transabdominal (LT) approach in the early 2000s.[1-3] Although a number of studies have reported the feasibility and safety of robotic LT adrenalectomy, it has not become popular because it has not been shown in the literature[1,4] to be more beneficial than laparoscopic adrenalectomy.

See Invited Critique at end of article

Although the laparoscopic posterior retroperitoneal (PR) approach has become an alternative to the LT technique for removing adrenal tumors over the last 2 decades, it has remained to be technically more demanding. The laparoscopic limitations are related to small working space, rigid instrumentation, and instrument collisions. When these shortcomings are considered, the use of the robot seems the logical way to improve this operation. Inspired by these drawbacks of laparoscopic PR adrenalectomy, we developed the robotic PR technique and reported the safety and feasibility in 2010.[5] Since then, we have established the technique beyond the learning curve.

The aim of our study is to compare the robotic PR adrenalectomy with the laparoscopic technique regarding perioperative outcomes. Our hypothesis was that the 2 approaches would have a similar perioperative outcome but that the operative time would be shorter with the

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robotic technique because of its more dexterous instrumentation.

METHODS

PATIENTS

Between 2009 and 2011, a total of 31 patients underwent unilateral robotic PR adrenalectomy. These patients were compared with 31 consecutive patients who underwent unilateral laparoscopic PR adrenalectomy before the onset of the robotic program. The patients were selected for the PR vs the TL approach using the selection criteria published before.[6] Data were extracted from a prospectively maintained, institutional review board–approved database. The parameters analyzed included age, sex, body mass index (calculated as weight in kilograms divided by height in meters squared), diagnosis, tumor size, skin-to-skin operative time, robotic docking time, estimated blood loss, presence of perioperative complications, postoperative day 1 and day 14 visual analog pain scores, and length of hospital stay.

SURGICAL TECHNIQUE

Our techniques for laparoscopic and robotic adrenalectomies have been described in detail before.[5-7] In brief, the patient is placed in a prone jackknife position after general anesthesia is established. Percutaneous ultrasonography is performed to map out the relationship between the 12th rib, the kidney, and the adrenal mass. The initial 12-mm trocar is placed about 1 cm below the 12th rib. A potential PR space is created using a balloon dissector under direct view. This is followed by two 5-mm trocars placed medially and laterally. Laparoscopic ultrasonography is performed in all cases. Adrenalectomy is performed using a grasper and a harmonic scalpel. The technique and the placement of trocars were the same for both laparoscopic and robotic procedures. All cases included in our study were performed by the 2 senior authors (E.B. and A.S.).

Postoperative pain was managed in the same way for all patients and included a combination of oral ibuprofen and/or acetaminophen, supplemented by intravenous ketorolac tromethamine and/or narcotics on a *pro re nata* basis. A patient's pain level was assessed by the nursing staff on postoperative day 1 and at the time of the first follow-up in the office using a visual analog scale in the range from 0 to 10, with 0 representing no pain at all and 10 representing the worst pain imaginable.

STATISTICAL ANALYSIS

Data were analyzed using JMP software version 9.0.0 (SAS Institute) and the t test and the χ^2 test. Data are expressed as mean (SEM) values. Statistical significance was reached at $P<.05$. The efficiencies of the procedures were compared by analyzing the skin-to-skin operative time, which includes the "docking time" in the robotic arm.

RESULTS

The 2 study groups were similar regarding age and sex. For the robotic and laparoscopic groups, the mean (SEM) body mass indices (27.5 [0.7] and 30.3 [0.8], respectively; $P=.08$) and the mean (SEM) tumor sizes (3.1 [0.2] cm [range, 0.9-6.0 cm] and 3.0 [0.2] cm [range, 0.9-7.2 cm], respectively; $P=.48$) were similar. There was no difference between the groups regarding diagnosis (**Table**).

Table. Demographic, Clinical, and Perioperative Parameters of the Robotic and Laparoscopic Groups

	Mean (SEM)		
Parameter	Robotic Group (n = 31)	Laparoscopic Group (n = 31)	*P* Value
Age, y	52.5 (2.3)	53.2 (2.0)	.37
BMI	27.5 (0.7)	30.3 (0.8)	.08
Sex, No. of patients			
Female	21	17	.22
Male	10	14	
Side, No. of patients			
Right	1	12	.53
Left	16	19	
Tumor size, cm	3.1 (0.2)	3.0 (0.2)	.48
Previous abdominal surgery, No. (%) of patients	6 (19)	7 (23)	.81
Operative time, min	163.2 (10.1)	165.7 (9.5)	.43
Estimated blood loss, mL	25.3 (10.3)	35.6 (9.9)	.24
Length of hospital stay, median, d	1	1	.41
Pain score			
Postoperative day 1	2.5 (0.3)	4.2 (0.4)	.008
Postoperative day 14	0.1 (0.1)	0.2 (0.1)	.53
Pathology, No. of patients			
Nonsecreting adrenocortical adenoma	8	9	.91
Aldosteronoma	6	8	
Pheochromocytoma	6	7	
Cushing	5	4	
Cyst	2	1	
Other[a]	4	2	

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

[a] Includes gastric cancer metastasis (n = 1), lung cancer metastasis (n = 1), lymphangioma (n = 1), and testosterone-secreting tumor (n = 1) in the robotic group and thyroid cancer metastasis (n = 1) and cystic lymphangioma (n = 1) in the laparoscopic group.

There was no conversion to open surgery in either group. The mean (SEM) skin-to-skin operative times were similar for patients in the robotic and laparoscopic groups (163.2 [10.1] and 165.7 [9.5] minutes, respectively; $P=.43$). The mean (SEM) docking time for the robotic approach was 19.1 (2.1) minutes. A significant improvement in the operative time occurred after the 10th procedure: the mean (SEM) operative time was 209.6 (38.5) minutes for the first 10 procedures and 139.1 (10.9) minutes for the last 21 procedures ($P<.0001$). When the last 21 patients who underwent PR adrenalectomy were compared with the 31 patients from the laparoscopic series, it was seen that the mean (SEM) operative time was shorter for the robotic group than for the laparoscopic group (139.1 [10.9] vs 167.7 [12.1] minutes, respectively; $P=.046$). The mean (SEM) estimated blood losses were similar in the robotic and laparoscopic groups (25.3 [10.2] and 35.6 [9.9] mL, respectively; $P=.24$). The median hospital stay was 1 day for both groups.

The robotic and laparoscopic groups were similar regarding overall postoperative narcotic use (78% vs 84% of patients, respectively; $P=.52$). Significantly more patients in the laparoscopic group than in the robotic group received intravenous ketorolac (74% vs 42% of patients, respectively; $P = .009$). The mean (SEM) visual analog scale pain score was significantly lower in the robotic group than in the laparoscopic group on postoperative day 1 (2.5 [0.3] vs 4.2 [0.4]; $P = .008$); however, the mean (SEM) pain scores for the groups were similar on postoperative day 14 (0.1 [0.1] vs 0.2 [0.1]; $P = .53$). There were no deaths or complications in either group (Table).

COMMENT

Our study shows that, beyond the learning curve for experienced laparoscopic surgeons, robotic PR adrenalectomy shortens the skin-to-skin operative time by 28 minutes compared with the laparoscopic approach. It also suggests that the immediate pain level of the patients may be lower after the robotic procedure. To our knowledge, this is the largest robotic PR adrenalectomy series reported to date and the first study to suggest an advantage of the robotic technique over the laparoscopic technique.

Previously, Brunaud et al[4] compared 50 patients who underwent a laparoscopic LT adrenalectomy with 50 patients who underwent a robotic LT adrenalectomy and found no evidence that the robotic technique was superior to the conventional laparoscopic approach for unilateral adrenalectomy. Subsequently, the first prospective randomized clinical trial comparing these procedures was reported by Morino et al.[8] They reported a 40% conversion rate from the laparoscopic approach to the robotic approach and concluded that laparoscopic adrenalectomy was superior to robotic adrenalectomy in terms of feasibility, length of hospital stay, cases of morbidity, and cost. In the same year, Brunaud et al[2] evaluated and compared the perioperative quality of life of patients after a laparoscopic adrenalectomy with that of patients after a robotic adrenalectomy and observed no difference between the procedures in terms of superiority of approach. Then, the same group (ie, Brunaud et al[4]) reported that, after a learning curve of 20 procedures, robotic adrenalectomy had perioperative outcomes that were similar to those associated with laparoscopic LT adrenalectomy regarding operative times, conversion rates, length of hospital stay, and morbidity.[4] In addition, they identified tumor side, previous clinical experience, and first assistant's skill as main predicting factors for operative time in robotic LT adrenalectomy. Our study adds to the literature by reporting additional comparative data between robotic and laparoscopic PR adrenalectomy.

In general, we prefer the PR approach in patients with tumors less than 6 cm in size, with an appropriate relationship between the 12th rib and the kidney, with a reasonably short distance between the skin and the Gerota fascia, and with significant abdominal adhesions and bilateral adrenal tumors. Because the abdominal cavity is not entered and there is direct access to the adrenal gland, there is minimal manipulation of other abdominal organs. For these reasons, the laparoscopic PR technique could be considered a less invasive approach compared with the LT technique. However, the PR approach is technically more demanding owing to the small working space and to the limitation of the range of motion with the rigid instruments. In our experience, the robotic approach has rendered this procedure more ergonomic. There is less instrument collision, and we feel that the dissection is faster and more accurate robotically.

We believe that there is still a need to improve the robotic technique. A robotic suction irrigator that can also be used for countertraction, an articulating vessel dividing-sealing device, and smaller robotic arms will further refine the technique. The procedure currently uses a single-port concept because the ports are placed very close to each other. This created a difficulty with the docking of the robot initially, but, with experience, we were able to reduce the docking time (from 20-30 minutes to 5-8 minutes).

One of the drawbacks of the robotic technique is that there is no room for an additional first-assistant port. Therefore, in cases of bleeding, we introduced a suction-irrigation cannula by removing one of the robotic instruments. This requires an experienced surgical team, both on the console and at the bedside. Despite treating a wide range of adrenal pathologies, including pheochromocytomas and malignant tumors, owing to our laparoscopic surgical experience, both the morbidity and mortality rates were 0% for both surgical groups. These results might not be reproducible in less experienced hands, and we recommend gaining robotic surgical experience by doing a number of LT adrenalectomies and getting comfortable with the laparoscopic PR technique before embarking on the robotic PR technique. In the literature,[7,9,10] the morbidity rate for laparoscopic PR adrenalectomy ranges from 1.3% to 15.9%.

Our robotic approach is different in many ways from the technique described in Ludwig et al.[11] After intubation on a gurney, a patient is placed in a prone jackknife position using a Wilson frame. In contrast to the technique described in Ludwig et al,[11] we do not tuck either of the arms; instead, both arms are placed on arm boards along the head of the table toward the anesthesiologist. We use 5-mm (instead of 8-mm) instruments to decrease collision. We keep the insufflation pressure at 15 mm Hg for most cases and increase it to 20 mm Hg only in cases with difficulty in establishing the space, whereas Ludwig et al[11] prefer to start with a higher insufflation pressure as recommended by Walz et al.[9] We perform the dissection using a 5-mm grasper and a harmonic scalpel. Finally, we prefer to ligate the adrenal vein, either by using the harmonic scalpel or a 5-mm endoscopic clip applier.

Although our study shows that the skin-to-skin operative time of the robotic approach is about 28 minutes shorter than that of the laparoscopic approach, the setup of the robotic system could take additional time, nullifying this intraoperative benefit. It is true that the transport of the robotic unit to the operating room, the start-up of the system, the calibration of the robotic camera, and the draping of the robotic arms can take up to 20 to 25 minutes. This is in addition to the docking time, which involves the attachment of the robotic arms to the trocars and the insertion of the robotic instruments to the field. We have solved this problem by keeping the robot in a dedicated operating room and by doing the additional setup during either the induction of anesthesia or the initial laparoscopic portion of the procedure. Therefore, there was no additional time spent setting up of the robot.

Brunaud et al[4] reported that the learning curve for the robotic LT approach was 20 procedures. In our series, we detected a significant decrease in operative time after the 10th procedure. First of all, we used a different type of approach than that used for the series of patients in Brunaud et al. Second, we use the robot for various other endocrine and general surgical procedures, which might account for the shorter learning curve in our series.

The cost of the robot is another concern that has not been analyzed in the present study. This cost includes the purchase and maintenance of the unit, as well as the robotic instruments used. The robotic units are frequently used by other surgical specialties at our institution, and therefore the economic pressure on an individual case is less in our practice; however, the cost is a serious issue for the future of robotic surgery, and a significant benefit needs to be demonstrated to justify the use of the robot for any surgical procedure. Overall, the cost of additional robotic instruments and drapes, as well as the annual maintenance fees per procedure, may add up to around \$900 to \$950 per robotic procedure. The decrease in operative time (ie, 28 minutes shorter) observed with the use of the robot in our study can help us to recover some of these costs because various reports[12,13] in the literature have suggested that standard operative room and anesthesia costs range from \$16 to \$21 per minute for various general surgical procedures.

Interestingly, in our patients, the immediate pain score was less after the robotic procedure. Although this needs to be verified by studies with a higher volume of patients, less pain might be related to a shorter operation time, less manipulation of the incisions with fewer instrument changes, and less pressure exerted by the surgical team on the patient's back to reach difficult angles with the articulating (vs rigid) instruments. As expected, the pain score at the first postoperative office visit was similar between groups.

In summary, as an update to our initial safety and efficacy report,[5] this study shows that, once you go beyond the learning curve, use of the robot shortens the operative time for PR adrenalectomy, with the possibility of less immediate postoperative pain. These results are encouraging. We believe that there is potential for further improvement in the technique with future advances in robotic instrumentation, and we hope that our report can encourage a multicenter randomized study.

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INVITED CRITIQUE

Robotic Posterior Retroperitoneal Adrenalectomy

For What Benefit and at What Cost?

Even before any randomized control trial was performed to compare laparoscopic adrenalectomy with open adrenalectomy, the lateral and retroperitoneal approaches to laparoscopic adrenalectomy were quickly adapted because laparoscopic adrenalectomy was associated with a superior patient outcome and lower costs. However, the benefit of robotic adrenalectomy, especially the lateral transabdominal approach, is thus far