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# Single-Port Robotic-Assisted Adrenalectomy: Feasibility, Safety, and Cost-Effectiveness

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## ABSTRACT

**Background and Objectives:** The introduction of robotic surgery offers patients and surgeons new options for adrenalectomy. Whereas multiport adrenalectomies have been safely performed using the robot, we describe our experience with the novel technique of single-port robotic-assisted adrenalectomy.

**Methods:** We performed a matched-cohort study comparing 16 single-port robotic-assisted adrenalectomies with 16 patients from a pool of 148 laparoscopic adrenalectomies, matched for age, gender, operative side, pathology, and body mass index. All were operated on by 1 surgeon.

**Results:** The pathology included aldosteronoma in 44% of patients, adrenocorticotropic hormone–dependent Cushing syndrome (bilateral adrenalectomy) in 19%, pheochromocytoma in 13%, and other pathology in 24%. The operative time was 183 ± 33 minutes for single-port robotic-assisted adrenalectomy and 173 ± 40 minutes for laparoscopic adrenalectomy ($P = .58$). The total time in the operating room was 246 ± 33 minutes for single-port robotic-assisted adrenalectomy and 240 ± 39 minutes for laparoscopic adrenalectomy ($P = .57$). There was 1 conversion to open adrenalectomy (6%) in each group, both because of bleeding on the right side during bilateral adrenalectomy. Two right-sided single-port robotic-assisted adrenalectomy patients required conversion to laparoscopic adrenalectomy, one because of poor visualization. There were no deaths. Complications occurred in 2 patients in each group (intensive care unit admission, prolonged ileus). Both groups had similar pain scores (mean of 3.7 on a scale from 1 to 10) on postoperative day 1, and patients in the single-port robotic-assisted adrenalectomy group used less narcotic pain medication in the first 24 hours after surgery (43 mg vs 84 mg in laparoscopic adrenalectomy group, $P < .001$). The differences between the single-port robotic-assisted adrenalectomy group and laparoscopic adrenalectomy group in length of stay (2.3 ± 0.5 days vs 3.1 ± 0.9 days, $P = .23$), percentage of patients discharged on postoperative day 1 (56% vs 31%, $P = .10$), and hospital cost (16% lower in single-port robotic-assisted adrenalectomy group, $P = .17$) did not reach statistical significance.

**Conclusion:** Single-port robotic adrenalectomy is feasible; patients require less narcotic pain medication whereas costs appear equivalent compared with laparoscopic adrenalectomy.

**Key Words:** Single port, Robotic, Adrenalectomy, Laparoscopic.

## INTRODUCTION

Since the introduction of laparoscopic transabdominal adrenalectomy in the early 1990s,[1] this procedure has dominated the practice and has become the standard of care for benign adrenal tumors. Multiple studies have reported less pain, a shorter hospital stay, and a quicker return to work for patients undergoing laparoscopic adrenalectomy (LA) compared with open adrenalectomy.[2] Single-site LA has been proposed in multiple small studies to be a safe alternative with potentially less pain and a shorter hospital stay compared with multiport LA.[3,4] However, it also has some known technical disadvantages, including crowding and clashing of instruments, ergonomic difficulties, loss of instrument triangulation, and need for advanced laparoscopic skills, that have prevented this approach from becoming a standard surgical technique.

Robotic surgery has the promise of overcoming these technical challenges by translating surgeon dexterity and enhancing surgical precision, visualization, and ergonomics.[5,6] Since its introduction a decade ago, robotic-assisted surgery has been used in many different surgical procedures, and adrenalectomy is not an exception. There are multiple reports of multiport robotic-assisted adrenalectomies performed in different centers, and many have reported feasibility and similar operative times with less

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morbidity and shorter hospital stays.[7] To our knowledge, there has been no report on single-port robotic-assisted adrenalectomy (SPRA). We describe our experience in the first 16 patients who underwent SPRA at our institution and compare their outcomes with matched historical control patients who underwent standard LA.

## METHODS

Our first SPRA was performed in November 2012. Patients were offered both laparoscopic and robotic techniques with detailed information and provided informed consent. We performed a matched-cohort study comparing our first 16 SPRA patients treated through August 2013 with 16 patients from a pool of 148 standard multiport LAs from August 2006 to August 2013. Patients were matched for age, gender, body mass index (BMI), operative side, tumor functional status, and tumor size using NCSS statistical software (NCSS, LLC, Kaysville, Utah). All patients in both groups were operated on by 1 surgeon (M.L.R.). Data were gathered from electronic records. The paired *t* test and Wilcoxon signed rank test were used to calculate differences between the 2 groups. Continuous data are expressed as mean ± standard error of mean.

### Technique

The patient is carefully positioned in a flexed lateral decubitus position. The kidney rest is raised, and the beanbag is used to position the patient, making sure that all pressure points are carefully padded. A left/right middle quadrant incision is made measuring 2.5 cm for the single-site port. For right-sided adrenalectomy, an additional 5-mm port is used to facilitate liver retraction. After the trocar is placed, the robot is docked and the remainder of the operation is performed in the standard fashion for LA.

## RESULTS

There were 8 men and 8 women included in each group, with a mean BMI of 32 kg/m$^2$ (range 22–42 kg/m$^2$) and a mean age of 51 years (range, 25–79 years). The pathology included aldosteronoma in 44% of patients (n = 14), adrenocorticotropic hormone (ACTH)–dependent Cushing syndrome (bilateral adrenalectomy) in 19% (n = 6), pheochromocytoma in 13% (n = 4), and other pathology in 24% (**Table 1**). All patients were matched based on their pathology except for 1 patient with ACTH-dependent Cushing syndrome with prior contralateral nephrectomy and adrenalectomy in the SPRA group who was matched to a patient with ACTH-nondependent Cushing syndrome (adenoma), both of whom underwent unilateral adrenalectomy.

The operative time from incision to closure was 183 ± 33 minutes for SPRA and 173 ± 40 minutes for LA ($P = .58$). The total time in the operating room (OR) from induction to exiting the OR was 246 ± 33 minutes for SPRA and 240 ± 39 minutes for LA ($P = .57$). When bilateral surgical procedures were excluded, operative times were shorter for unilateral adrenalectomy (130 ± 8 minutes for SPRA and 188 ± 12 minutes for LA).

There was 1 conversion to open adrenalectomy (6%) in each group, both because of bleeding on the right side during bilateral adrenalectomy for ACTH-dependent Cushing syndrome. In 2 other SPRA patients (12%), conversion to LA was required on the right side (the right side of a bilateral adrenalectomy) because of dense inflammatory reaction around the gland in 1 patient and because of difficulty visualizing due to the inability to retract the colon properly in 1 patient. A conversion to multiport robotic adrenalectomy would have been feasible, but having the immediate availability of the multiport instrumentation in every case was not practical. Complications occurred in 2 patients (12%) in each group. One patient in each group had a prolonged ileus. One patient in the LA group required intensive care unit admission for postoperative bleeding but did not require surgical intervention. In 1 patient in the SPRA group with a history of metastatic medullary thyroid carcinoma, hypocalcemia and respiratory distress developed. There were no perioperative deaths.

The pain scores for postoperative day 1 were recorded from the electronic medical record using a 10-cm visual analog scale. Use of narcotic pain medication was calculated in the first 24 hours after surgery and reported in morphine equivalents (**Figure 1**). Whereas both groups had similar pain scores (3.7 ± 0.6 vs 3.7 ± 0.5) on the morning of the day after surgery, patients in the SPRA group had statistically significantly lower narcotic use in the first 24 hours after surgery (43 mg vs 84 mg in LA group, $P < .001$).

Length of stay, though not statistically significant ($P = .23$), was 0.8 days (27%) shorter in the SPRA group than in the LA group (2.3 ± 0.5 days vs 3.1 ± 0.9 days). In another words, 56% of SPRA patients (9 of 16) were discharged on postoperative day 1 compared with 31% of LA patients (5 of 16). Again, this did not reach statistical significance ($P = .10$).

Cost analysis showed that the SPRA technique was 16% less expensive than the LA technique (84% ± 14% vs

**Table 1.**
Demographic, Clinical, and Surgical Parameters

| | SPRA[a] | LA[a] | *P* Value |
|---|---|---|---|
| Mean age, y | 53.4 ± 3.9 | 49.1 ± 3.2 | .18 |
| Gender (male/female) | 8/8 | 8/8 | |
| BMI,[a] kg/m$^2$ | 31.8 ± 1.3 | 32.6 ± 0.9 | .47 |
| Gland size, cm | 5.9 ± 0.4 | 6.6 ± 0.5 | .06 |
| Tumor size, cm | 3.6 ± 0.7 | 3.4 ± 0.8 | .79 |
| Side (left/right/bilateral), n | 9/4/3 | 9/4/3 | |
| Tumor type, n | | | .96 |
| Aldosteronoma | 7 | 7 | |
| ACTH[a]-dependent Cushing syndrome | 4 | 3 | |
| Pheochromocytoma | 2 | 2 | |
| Other | 3 | 4 | |
| EBL,[a] mL | 576 ± 377 | 618 ± 372 | .68 |
| OR[a] time, min | 246 ± 33 | 240 ± 39 | .57 |
| Operative time, min | 183 ± 33 | 173 ± 40 | .63 |
| Unilateral operative time, min | 130 ± 8 | 118 ± 12 | .79 |
| LOS,[a] d | 2.3 ± 0.5 | 3.1 ± 0.9 | .23 |
| Pain score (1–10) | 3.7 ± 0.5 | 3.7 ± 0.6 | .93 |
| Narcotic use,[b] mg | 42.9 ± 5.1 | 84.3 ± 13.5 | < .001 |
| Conversion, n (%) | | | |
| Conversion to open | 1 (6%) | 1 (6%) | |
| Conversion to laparoscopic | 2 (12%) | — | |
| Relative cost | 0.84 ± 0.14 | 1 ± 0.17 | .08 |

Continuous data are expressed as mean ± standard error of mean.

[a]ACTH = adrenocorticotropic hormone; BMI = body mass index; EBL = estimated blood loss; LA = laparoscopic adrenalectomy; LOS = length of stay; OR = operating room; SPRA = single-port robotic adrenalectomy.

[b]Morphine equivalent of narcotic used in first 24 hours postoperatively.

100% ± 16%). This difference did not reach statistical significance ($P$ = .17) (**Figure 2**).

We performed the analysis again excluding bilateral surgery, and the differences between the groups persisted for OR time (195 ± 11 vs 185 ± 11 minutes, $P$ = .56), operative time (130 ± 8 minutes vs 188 ± 12 minutes, $P$ = .49), length of stay (1.6 ± 0.4 days vs 2.1 ± 0.3 days, $P$ = .40), and cost (87% ± 3% vs 100% ± 11%, $P$ = .09).

## DISCUSSION

We report 16 single-site robotic-assisted adrenalectomy cases; to our knowledge, this is the first report on this technique. We have shown that this technique is feasible with no deaths and acceptable morbidity compared with the standard multiport laparoscopic technique.

The limitations of our study are that it is a retrospective study and has a small sample size. However, because this is a novel technique, we decided to evaluate our experience early on. By matching the patients to historical control patients and having all procedures (both LA and SPRA) performed by the same surgeon, we minimized the effects of confounding factors.

Our patients' demographic characteristics were similar to those in other studies on LA. Elfenbein et al,[8] in their review of 3100 patients undergoing adrenalectomy retrieved from American College of Surgeons National Sur-

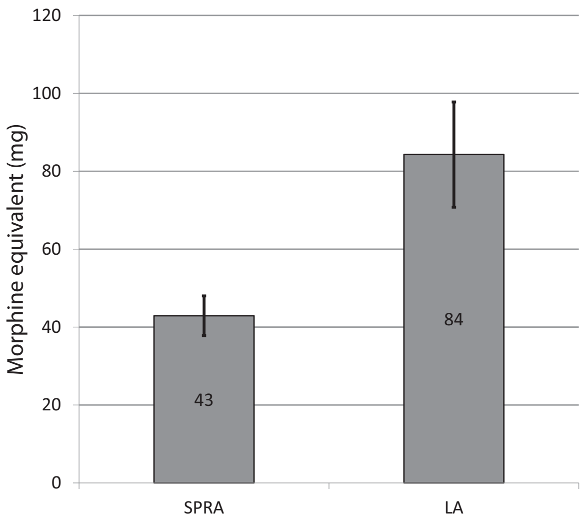


**Figure 1.** Narcotic pain medication use in first 24 hours. Bars indicate standard error of mean. LA = laparoscopic adrenalectomy; SPRA = single-port robotic adrenalectomy.

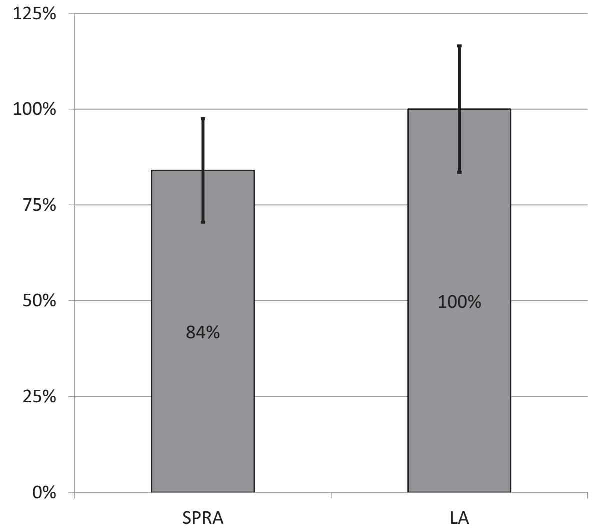


**Figure 2.** Cost relative to laparoscopic adrenalectomy. Bars indicate standard error of mean. LA = laparoscopic adrenalectomy; SPRA = single-port robotic adrenalectomy.

gical Quality Improvement Program data, found that the mean age of patients was 53 years and the mean BMI was 29 kg/m$^2$ for LA. Our patients were similar in age but had a slightly higher BMI on average.

The rate of conversion to an open technique from a laparoscopic technique has been reported to be 5.5% to 16% and from robotic adrenalectomy, 3% to 4%.[9–13] Our conversion rate to an open technique was similar (6%), but the rate of conversion to a 4-port laparoscopic technique was higher. This finding may have been related to more challenging patient selection with combined obesity and hypercortisolism. We suspect that this may change as experience and comfort with the robotic technique improve.

Aliyev et al[9] in 2013 reported their experience with multiport robotic adrenalectomy for pheochromocytoma in 25 patients and reported operative times to be similar for robotic adrenalectomy and LA: 149 minutes versus 178 minutes. Similarly, in their 100-case series of robotic adrenalectomy, Brunaud et al[11] in 2008 reported a 99-minute operative time. Our study, using the novel single-site robotic technique, showed comparable results, with operative times of 182 minutes when including bilateral surgeries and 130 minutes for unilateral single-site robotic adrenalectomy.

The length of hospital stay after robotic adrenalectomy has been reported as 1.2 to 6.4 days.[9,11] Our SPRA patients left the hospital on average after 2.3 days compared with 3.1 days for laparoscopic patients (0.8 days earlier). Although the difference did not reach statistical significance, it may be of cost-savings significance. Aliyev et al[9] reported that their robotic patients left the hospital on average 1 day earlier, and they found the result to be statistically significant.

One of the major concerns regarding the robot is the cost of the unit, including the initial purchase, subsequent maintenance, and instruments used in each case. Currently, there are no specific codes for robotic adrenalectomy, and reimbursement is the same as that for the laparoscopic technique. It has been calculated that a robotic procedure adds about $950 to the cost compared with LA.[9] However, shorter hospital stays with improved pain management might compensate for the difference. Our finding that the robotic technique cost 16% less may be related to a shorter hospital stay related to an approximately 50% reduction in narcotic use.

Single-site robotic adrenalectomy is feasible with comparable results with LA. It may offer the advantage of less narcotic use. Moreover, although our data did not have enough power to show any significant differences, we suspect that with less narcotic use, the hospital stay will shorten and this might result in lower costs. We expect our results to continually improve as we expand outside the learning curve.

**References:**

1. Gagner M, Lacroix A, Bolte E. Laparoscopic adrenalectomy in Cushing's syndrome and pheochromocytoma. *N Engl J Med*. 1992;327(14):1033.

2. Thompson GB, Grant CS, van Heerden JA, et al. Laparoscopic versus open posterior adrenalectomy: a case-control study of 100 patients. *Surgery*. 1997;122(6):1132–1136.

3. Wang L, Wu Z, Li M, et al. Laparoendoscopic single-site adrenalectomy versus conventional laparoscopic surgery: a systematic review and meta-analysis of observational studies. *J Endourol*. 2013;27(6):743–750.

4. Vidal O, Astudillo E, Valentini M, Ginesta C, Garcia-Valdecasas JC, Fernandez-Cruz L. Single-incision transperitoneal laparoscopic left adrenalectomy. *World J Surg*. 2012;36(6):1395–1399.

5. Jung YW, Kim YT, Lee DW, et al. The feasibility of scarless single-port transumbilical total laparoscopic hysterectomy: initial clinical experience. *Surg Endosc*. 2010;24(7):1686–1692.

6. Boggess JF, Gehrig PA, Cantrell L, et al. A comparative study of 3 surgical methods for hysterectomy with staging for endometrial cancer: robotic assistance, laparoscopy, laparotomy. *Am J Obstet Gynecol*. 2008;199(4):360.e1–360.e9.

7. Taskin HE, Arslan NC, Aliyev S, Berber E. Robotic endocrine surgery: state of the art. *World J Surg*. 2013;37(12):2731–2739.

8. Elfenbein DM, Scarborough JE, Speicher PJ, Scheri RP. Comparison of laparoscopic versus open adrenalectomy: results from American College of Surgeons-National Surgery Quality Improvement Project. *J Surg Res*. 2013;184(1):216–220.

9. Aliyev S, Karabulut K, Agcaoglu O, et al. Robotic versus laparoscopic adrenalectomy for pheochromocytoma. *Ann Surg Oncol*. 2013;20(13):4190–4194.

10. Karabulut K, Agcaoglu O, Aliyev S, Siperstein A, Berber E. Comparison of intraoperative time use and perioperative outcomes for robotic versus laparoscopic adrenalectomy. *Surgery*. 2012;151(4):537–542.

11. Brunaud L, Ayav A, Zarnegar R, et al. Prospective evaluation of 100 robotic-assisted unilateral adrenalectomies. *Surgery*. 2008;144(6):995–1001; discussion 1001.

12. Lubikowski J, Uminski M, Andrysiak-Mamos E, et al. From open to laparoscopic adrenalectomy: thirty years' experience of one medical centre. *Endokrynol Pol*. 2010;61(1):94–101.

13. Shen ZJ, Chen SW, Wang S, et al. Predictive factors for open conversion of laparoscopic adrenalectomy: a 13-year review of 456 cases. *J Endourol*. 2007;21(11):1333–1337.