

# Perioperative Outcomes of Robotic Assisted Laparoscopic Surgery Versus Conventional Laparoscopy Surgery for Advanced-Stage Endometriosis

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## ABSTRACT

**Background and Objectives:** To determine perioperative outcome differences in patients undergoing robotic-assisted laparoscopic surgery (RALS) versus conventional laparoscopic surgery (CLS) for advanced-stage endometriosis.

**Methods:** This retrospective cohort study at a minimally invasive gynecologic surgery center at 2 academically affiliated, urban, nonprofit hospitals included all patients treated by either robotic-assisted or conventional laparoscopic surgery for stage III or IV endometriosis (American Society for Reproductive Medicine criteria) between July 2009 and October 2012 by 1 surgeon experienced in both techniques. The main outcome measures were extent of surgery, estimated blood loss, operating room time, intraoperative and postoperative complications, and length of stay, with medians for continuous measures and distributions for categorical measures, stratified by body mass index values. Robotically assisted laparoscopy and conventional laparoscopy were then compared by use of the Wilcoxon rank sum,  $\chi^2$ , or Fisher exact test, as appropriate.

**Results:** Among 86 conventional laparoscopic and 32 robotically assisted cases, the latter had a higher body mass index (27.36 kg/m<sup>2</sup> [range, 23.90–34.09 kg/m<sup>2</sup>] versus 24.53 kg/m<sup>2</sup> [range, 22.27–26.96 kg/m<sup>2</sup>];  $P < .0079$ ) and operating room time (250.50 minutes [range, 176–328.50 minutes] versus 173.50 minutes [range, 123–237 minutes];  $P < .0005$ ) than did conventional laparoscopy patients. After body mass index stratification, obese patients varied in operating room time (282.5 minutes [range, 224–342 minutes] for robotic-assisted laparoscopy versus 174 minutes [range, 130–270 minutes] for conventional laparoscopy;  $P < .05$ ). No other significant differ-

ences were noted between the robotic-assisted and conventional laparoscopy groups.

**Conclusion:** Despite a higher operating room time, robotic-assisted laparoscopy appears to be a safe minimally invasive approach for patients, with all other perioperative outcomes, including intraoperative and postoperative complications, comparable with those in patients undergoing conventional laparoscopy.

**Key Words:** Conventional versus robotic-assisted laparoscopic surgery, Advanced-stage endometriosis, Conventional laparoscopic surgery, Robotic-assisted laparoscopic surgery, Endometriosis stage III, Endometriosis stage IV.

## INTRODUCTION

Endometriosis is a gynecologic disorder defined as the presence of endometrial glands and stroma outside the uterine cavity. It affects an estimated 6% to 15% of reproductive-age women,<sup>1,2</sup> 20% to 50% of infertile women,<sup>3</sup> and 71% to 87% of women with chronic pelvic pain.<sup>4</sup> Worldwide, there are over 70 million women and adolescents affected by endometriosis,<sup>5</sup> with an estimated 5.5 million women in the United States and Canada, and approximately 51 000 hospitalizations for endometriosis yearly.<sup>6</sup> The disease results in decreased quality of life ranging from chronic pelvic pain to infertility.<sup>5</sup> The range of severity of disease can vary widely, as can the means of treating it.<sup>7,8</sup> Current recommendations include treatment with a trial of nonsteroidal anti-inflammatory agents and hormonal therapy, such as progesterone, oral contraceptives, aromatase inhibitors, or gonadotropin-releasing hormone agonists, but eradication by surgical means is often the most effective treatment.<sup>9</sup> Depending on the pervasiveness of the disease, multiple surgical interventions may be indicated to successfully manage this condition.

Minimally invasive techniques have been proved to be feasible in treating endometriosis and have been increasingly used in the treatment of this complex disease.<sup>9</sup> Conventional laparoscopy has several proven advantages over laparotomy, including faster postoperative recuperation, shorter length of hospital stay, cosmetic benefits,

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improved intraoperative visualization, decreased blood loss, and fewer complications.<sup>10–12</sup> However, several other attributes of conventional laparoscopy, including the 2-dimensional view, counterintuitive hand movements, gradual learning curve, operator fatigue, tremor amplification, and availability of proper instrumentation, may impede the use of this technology by the less experienced surgeon.<sup>13–15</sup>

Computer-enhanced telesurgery, or robotic-assisted surgery, attempts to overcome the disadvantages of conventional laparoscopy by offering improved dexterity, coordination, and visualization and by decreasing surgeon fatigue.<sup>16–19</sup> The aim of this article is to compare perioperative outcomes in patients undergoing robotic-assisted laparoscopy with those undergoing conventional laparoscopy for advanced-stage endometriosis. Surgical management of advanced-stage endometriosis requires complex pelvic dissection, which can increase the operating time, intraoperative and postoperative complications, and rate of conversion to laparotomy.

## MATERIALS AND METHODS

Included in the study were all patients treated between July 2009 and October 2012 with conventional laparoscopic surgery (CLS) or robotic-assisted (da Vinci; Intuitive Surgical, Sunnyvale, California) laparoscopic surgery (RALS) for stage III or IV endometriosis based on the revised American Society for Reproductive Medicine criteria.<sup>20</sup> All procedures were performed by 1 surgeon experienced in robotic-assisted and conventional laparoscopy, assisted by minimally invasive surgery fellows and/or an obstetrics/gynecology resident. The surgeon decided the route of each procedure based on obesity, expected complexity of disease, previous and planned surgical procedures, and availability of the robotic platform. Institutional Review Board approval was obtained from St. Luke's-Roosevelt Hospital Center.

All data were collected from our prospectively maintained computerized database of RALS and CLS procedures. Demographic data included age, race, body mass index (BMI, calculated as weight in kilograms/square of height in meters), and previous abdominal or pelvic surgical procedures. Surgical data included a description of the procedure performed; estimated blood loss (EBL), that is, the amount of fluid in the suction canister at the end of the procedure minus the total amount of irrigation; operative time (ORT), from the inception of the first surgical procedure (hysteroscopy, dilation and curettage, and so on) to the completion of all skin closures; intraoperative compli-

cations; postoperative complications; and length of stay (LOS), measured in days, with patients discharged the day of surgery considered to have an LOS of 1 day.

All procedures began as standard laparoscopy, with the subsequent docking of the robot into the surgical field.<sup>21</sup> Patients undergoing the RALS procedure were placed in the dorsal lithotomy position, and a uterine manipulator and Foley catheter were placed. RALS port placement consisted of an umbilical or supraumbilical 12-mm camera port, 8-mm robotic ports in the right and left sides of the mid abdomen, and a 5- to 12-mm assistant port in the right or left upper quadrant. For excision of endometriosis, monopolar scissors or a spatula was inserted through the right robotic trocar and a bipolar forceps was inserted through the left robotic trocar. These instruments were exchanged for robotic needle holders as needed. Other instruments such as a suction/irrigator, grasper, specimen retrieval bag, and blood sealing device were introduced from the assistant port.<sup>22</sup> The primary surgeon was sitting at the robot console while the left upper quadrant port was used by the first assistant to provide ancillary laparoscopic assistance as needed by the surgeon.

In the other group, CLS port placement consisted of a periumbilical 5- to 10-mm port, 5-mm ports in both the right and left lower quadrants, and a 5- to 10-mm supra-pubic port in certain cases. In the CLS cases, the equipment used for excision of endometriosis included electro-surgical monopolar scissors, Harmonic Wave coagulating shears (Ethicon, Somerville, New Jersey), a carbon dioxide laser, and/or a PlasmaJet energy system (Plasma Surgical, Inc. Roswell, GA, USA).<sup>23</sup> Other ancillary instruments such as a vessel sealing device, suction/irrigator, or Kleppinger bipolar system (Richard Wolf Instruments, Vernon Hills, IL, USA) were used as needed. Fascia closure was performed using the laparoscopic closure device for all incisions longer than 8 mm, as well as for 8-mm robotic trocar sites, which increased in diameter because of a lengthy procedure. The skin layer was closed in a subcuticular manner with overlying Nexcare Steri-Strip Skin Closures (3M, St. Paul, MN, USA).

Within each group (CLS or RALS), the techniques and instrumentation were uniform down to the last detail, including those used in specific procedures such as ureterolysis, ureteral resection and reimplantation, bowel resection, and bladder resection.

In all cases, the postoperative course was monitored for 30 days. Parameters such as hospital LOS and postoperative complications were collected.

**Table 1.**

Perioperative Outcomes

	CLS <sup>a</sup> (n = 86)	RALS <sup>a</sup> (n = 32)	P Value
EBL <sup>a</sup> (range) (mL) <sup>b</sup>	100 (50–200)	100 (50–200)	.8755
ORT <sup>a</sup> (range) (min) <sup>b</sup>	173.50 (123–237)	250.50 (176–328.50)	.0005 <sup>d</sup>
Hysterectomy <sup>c</sup>			.1065
None	68 (79%)	24 (75%)	
Simple	18 (21%)	6 (19%)	
Radical	0 (0%)	2 (6%)	
Hysteroscopy <sup>c</sup>			.0900
Not performed	36 (42%)	19 (59%)	
Performed	50 (58%)	13 (41%)	
No. of intraoperative complications <sup>c</sup>			.2712
0	86 (100%)	31 (97%)	
1	0 (0%)	1 (3%)	
No. of postoperative complications <sup>c</sup>			.6570
0	76 (88%)	27 (84%)	
1	8 (9%)	4 (13%)	
2	1 (1.5%)	0 (0%)	
3	1 (1.5%)	1 (3%)	
LOS <sup>a</sup> (range) (d) <sup>b</sup>	1 (0–2)	1 (0–2)	.5582

<sup>a</sup>CLS = conventional laparoscopic surgery; EBL = estimated blood loss; LOS = length of stay in hospital after surgery; ORT = operating room time; RALS = robotic-assisted laparoscopic surgery.

<sup>b</sup>Wilcoxon rank sum test at 5% (2-sided) level of significance.

<sup>c</sup>Chi-square test, or Fisher exact test when expected cell counts were <5, at 5% (2-sided) level of significance.

<sup>d</sup>P < .05.

### Statistical Analysis

The patient characteristics of age, BMI, BMI category, race, and extent of surgery were compared between the RALS and CLS groups, as were the outcome variables of EBL, ORT, LOS, intraoperative complications, and postoperative complications. For the continuous variables (age, BMI, EBL, and ORT), medians and first and third quartiles were calculated; comparisons of medians between the RALS and CLS groups were made with the Wilcoxon rank sum test. The categorical variable distributions (race, extent of surgery, intraoperative complications, postoperative complications, and BMI category) were compared between the RALS and CLS groups by the  $\chi^2$  test or, when the expected cell counts were <5, with the Fisher exact test.

In addition, patients were stratified into 3 BMI categories: normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight (25.0–29.9 kg/m<sup>2</sup>), and obese ( $\geq$ 30.0 kg/m<sup>2</sup>). Within each BMI cat-

egory, the same comparisons were made between the RALS and CLS groups as outlined earlier.

All statistical analyses were performed with SAS software, version 9.2 (SAS Institute, Cary, North Carolina). All hypothesis testing was conducted at the 5% (2-sided) level of significance.

## RESULTS

### Patient Characteristics

The study population included a total of 118 patients. Thirty-two patients underwent a robotic procedure for advanced-stage endometriosis. Of these, 24 (75%) had stage III and 8 (25%) had stage IV endometriosis. In the CLS arm, 86 patients underwent a laparoscopic procedure for advanced-stage endometriosis. Of these, 77 (89.5%) had stage III and 9 (10.5%) had stage IV endometriosis.

The median age was 39 years (range, 33.5–44 years) in the RALS group and 38 years (range, 31–44 years) in the CLS group. The median BMI in the RALS group was 27.36 kg/m<sup>2</sup> (range, 23.90–34.09 kg/m<sup>2</sup>), whereas that in the CLS group was 24.53 kg/m<sup>2</sup> (range, 22.27–26.96 kg/m<sup>2</sup>). In the RALS group, 22 of 32 patients (68.8%) underwent a previous pelvic operation, compared with 53 of 86 patients (61.6%) in the CLS group.

The median BMI in the RALS group was 27.36 kg/m<sup>2</sup> (range, 23.90–34.09 kg/m<sup>2</sup>), whereas that in the CLS group was 24.53 kg/m<sup>2</sup> (range, 22.27–26.96 kg/m<sup>2</sup>). This was a significant difference ( $P = .0079$ ), whereas there were no significant differences in stage of disease, age, or incidence of previous pelvic surgery.

**Perioperative Outcomes**

The median ORT was 250.50 minutes with the robot compared with 173.50 minutes for conventional laparoscopy ( $P < .0005$ ). There was no statistical difference between the 2 groups in hysterectomy rate, concurrent non-laparoscopic procedures (eg, hysteroscopy), EBL, or LOS (**Table 1**) or in rates of intraoperative or postoperative complications (**Table 2**). No conversions to laparotomy were reported in either group.

**BMI Stratification**

In the CLS and RALS groups, the normal-weight patients numbered 49 and 12, respectively; overweight, 26 and 6, respectively; and obese, 11 and 14, respectively. When comparisons of patient characteristics and perioperative outcomes between the RALS and CLS groups were made among obese patients, the only significant difference was that those who underwent RALS had a higher median ORT than those who underwent CLS (282.5 minutes [range, 224–342 minutes] versus 174 minutes [range, 130–270 minutes];  $P < .05$ ) (**Table 3**). However, among normal-weight and overweight patients, no significant differences were found between the RALS and CLS groups for ORT or any other factor.

**DISCUSSION**

Laparoscopy has been shown to play a pivotal role in the diagnosis and treatment of endometriosis,<sup>24–26</sup> with its key advantage being the ability to remove visible lesions while restoring the anatomy.

Scant published data exist comparing the robotic minimally invasive approach with the conventional laparoscopic approach for the treatment of endometriosis. A

**Table 2.**  
Postoperative Complications

Postoperative Complication	Minor/ Major	CLS <sup>a</sup> (n = 86)	RALS <sup>a</sup> (n = 32)
Blood transfusion	Minor	2	—
DVT <sup>a</sup>	Minor	1	—
Neuropathy	Minor	—	—
Lymphocyst	Minor	—	—
Fever	Minor	—	2
UTI <sup>a</sup>	Minor	1	—
Wound separation	Minor	—	—
Wound infection	Minor	1	—
Wound cellulitis	Minor	—	—
Atrial fibrillation/ECG <sup>a</sup> changes	Minor	—	—
Acute delirium	Minor	—	—
Ileus	Minor	—	1
Bowel obstruction treated medically	Minor	—	—
Hydroureter	Minor	—	—
Myocardial infarction	Major	—	—
CVA <sup>a</sup>	Major	—	—
CHF <sup>a</sup>	Major	—	—
Pulmonary embolus	Major	—	—
Bowel perforation	Major	—	1
Anastomotic complication	Major	—	—
Bowel obstruction treated surgically	Major	—	—
Placement of device	Major	—	—
Wound dehiscence	Major	—	—
Peritoneal vaginal fistula	Major	—	—
GU <sup>a</sup> fistula	Major	—	—
GI <sup>a</sup> fistula	Major	1	1
Death within 30 d	Major	—	—

<sup>a</sup>CHF = congestive heart failure; CLS = conventional laparoscopic surgery; CVA = cerebrovascular accident; DVT = deep vein thrombosis; ECG = electrocardiogram; GI = gastrointestinal; GU = genitourinary; RALS = robotic-assisted laparoscopic surgery; UTI = urinary tract infection.

retrospective study by Nezhat et al<sup>26</sup> is, to date, the largest to compare treatment by RALS (40 patients) versus CLS (38 patients) in patients with various stages of endometriosis. In these groups, only 9 robotic-surgery patients and 8 conventional laparoscopy patients had severe endometriosis. It was found that robot-assisted laparo-

**Table 3.**  
Characteristics and Perioperative Outcomes of Obese Patients (BMI<sup>a</sup> ≥30 kg/m<sup>2</sup>)

Characteristic or Outcome	CLS <sup>a</sup> (n = 11)	RALS <sup>a</sup> (n = 14)	P Value
Age <sup>b</sup> (range) (y)	40 (32–50)	42.5 (36–45)	>.99
ORT <sup>a</sup> (range) (min) <sup>b</sup>	174 (130–270)	282.5 (224–342)	.0255 <sup>d</sup>
EBL <sup>a</sup> (range) (mL) <sup>b</sup>	150 (10–200)	100 (50–200)	.6606
Hysterectomy <sup>c</sup>			.6619
None	8 (73%)	9 (64%)	
Simple	3 (27%)	3 (21%)	
Radical	0 (0%)	2 (14%)	
Hysteroscopy <sup>c</sup>			.6951
Not performed	5 (45%)	8 (57%)	
Performed	6 (55%)	13 (43%)	
No. of intraoperative complications <sup>c</sup>			NE <sup>a</sup>
0	11 (100%)	14 (100%)	
1	0 (0%)	0 (0%)	
No. of postoperative complications <sup>c</sup>			.2878
0	8 (73%)	3 (93%)	
1	3 (27%)	1 (7%)	
2	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	
LOS <sup>a</sup> (range) (d) <sup>b</sup>	1 (0–2)	1 (0–1)	.8626

<sup>a</sup>BMI = body mass index; CLS = conventional laparoscopic surgery; EBL = estimated blood loss; LOS = length of stay in hospital after surgery; NE = not estimable (neither group has any complications); RALS = robotic-assisted laparoscopic surgery.

<sup>b</sup>Wilcoxon rank sum test at 5% (2-sided) level of significance.

<sup>c</sup>Chi-square test, or Fisher exact test when expected cell counts were <5, at 5% (2-sided) level of significance.

<sup>d</sup>*P* < .05.

scopic and conventional laparoscopic treatment of endometriosis showed no statistically significant differences in outcomes, except for a longer operating time for the robotic surgical technique. In another retrospective cohort study, Bedaiwy et al<sup>27</sup> reviewed 43 cases of severe endometriosis treated with robot-assisted laparoscopy and found it to be a reasonably safe and feasible method for definitive surgical management of this condition. Siesto et al<sup>28</sup> published a retrospective cohort study of 43 patients with deep infiltrating endometriosis (DIE) treated by RALS, including 19 bowel resections, 23 removals of nodules from the rectovaginal septum, and 5 bladder resections; they found the robotic approach to be a safe and attractive alternative to accomplish comprehensive surgical treatment of DIE.

Several case reports showing the feasibility of robotic-assisted laparoscopy in cases of severe endometriosis in-

volving the bladder, rectum, and bowel have been published. Chammas et al<sup>29</sup> published a case report about a 23-year-old woman with a 4-cm bladder mass and rectal nodules confirmed to be endometriosis; she successfully underwent robotic-assisted laparoscopic partial cystectomy with excision of rectal nodules for endometriosis. Another case report of bladder endometriosis successfully removed by RALS, this time in a 32-year-old woman, was published by Liu et al.<sup>30</sup> In Brazil, Averbach et al<sup>31</sup> published a case report in which a 35-year-old woman with DIE with rectal involvement underwent colorectal resection by use of a robot; they found it to be a safe and feasible approach. A case series published by Nezhat et al<sup>32</sup> showed the advantage of the RALS approach in treating 5 patients with multiorgan endometriosis, including bowel, bladder, and ureteral endometriosis, concluding that robotic-assisted laparoscopy may provide the ade-

quate platform for inexperienced laparoscopic surgeons in converting those complex procedures from the laparotomy approach to the minimally invasive approach.

To date, this report is the largest published comparison of robotic versus conventional laparoscopy in the treatment of advanced-stage endometriosis. Our data suggest that even though there is a longer operating time in the RALS group compared with the CLS group, implementation of this new technology might allow a safe minimally invasive surgical approach in obese patients, with clinical outcomes comparable with those in nonobese patients undergoing conventional laparoscopy. Our results are not in agreement with those of Bedaiwy et al,<sup>27</sup> who concluded that the unique features of the robotic platform may offer advantages over conventional laparoscopy when endometriosis is severe, because our outcomes were comparable between the 2 surgical types without any statistically significant difference.

Nezhat et al<sup>26</sup> discussed the potential advantages of the 3-dimensional robot technology over the traditional 2-dimensional flat view of the surgical field in conventional laparoscopy when treating endometriosis at different stages of severity. The study concluded that perhaps the use of computer-enhanced technology should be reserved as an enabling device for more advanced cases. In our cohort, even when treating patients with advanced-stage endometriosis, we found no statistically significant difference in perioperative outcomes between robot-assisted laparoscopy and conventional laparoscopy.

We suggest that the robotic platform, because of its cost and intricacy, should be reserved and used only for complex operations that require fine dissection and lengthy procedures. By doing so, surgeon fatigue will be decreased.

This study has distinct weaknesses and strengths to be considered when interpreting the results. It is the largest comparison of RALS with CLS for advanced laparoscopy to date. In addition, there is a very high degree of uniformity in the treatment of all patients: All surgical procedures were conducted by 1 surgeon very experienced in both techniques, in 1 center, with 1 setting, and always, with the assistance of a fellow and/or a senior obstetrics/gynecology resident.

The weaknesses of the study are its retrospective nature, the small sample size, and potential selection bias introduced by placing each patient into her treatment cohort. The choice of surgical treatment was based on the first author's experience that the main advantages of the ro-

botic platform are found in treating obese patients and complex disease, as well as based on the availability of the robotic platform because not every operating room has one.

If we are to make the best possible comparison between RALS and CLS in the treatment of advanced-stage endometriosis, a prospective, randomized trial must be conducted, with an increase in sample size. In addition, observing patients over extended periods would permit evaluation of long-term outcomes.

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