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Can Teamwork and High-Volume Experience Overcome Challenges of Lymphadenectomy in Morbidly Obese Patients (Body Mass Index of 40 kg/m² or Greater) with Endometrial Cancer?

A Cohort Study of Robotics and Laparotomy and Review of Literature

Hubert Fornalik, MD,* Temeka Zore, MD,† Nicole Fornalik, PA-C,* Todd Foster, PhD,‡
Adrian Katschke, MS,‡ and Gary Wright, DO§

Objective: This study aimed to compare surgical outcomes and the adequacy of surgical staging in morbidly obese women with a body mass index (BMI) of 40 kg/m² or greater who underwent robotic surgery or laparotomy for the staging of endometrioid-type endometrial cancer.

Methods: This is a retrospective cohort study of patients who underwent surgical staging between May 2011 and June 2014. Patients' demographics, surgical outcomes, intraoperative and postoperative complications, and pathological outcomes were compared.

Results: Seventy-six morbidly obese patients underwent robotic surgery, and 35 underwent laparotomy for surgical staging. Robotic surgery was associated with more lymph nodes collected with increasing BMI ($P < 0.001$) and decreased chances for postoperative respiratory failure and intensive care unit admissions ($P = 0.03$). Despite a desire to comprehensively stage all patients, we performed successful pelvic and paraaortic lymphadenectomy in 96% versus 89% ($P = 0.2$) and 75% versus 60% ($P = 0.12$) of robotic versus laparotomy patients, respectively. In the robotic group, with median BMI of 47 kg/m², no conversions to laparotomy occurred. The robotic group experienced less blood loss and a shorter length of hospital stay than the laparotomy group; however, the surgeries were longer.

Conclusions: In a high-volume center, a high rate of comprehensive surgical staging can be achieved in patients with BMI of 40 kg/m² or greater either by laparotomy or robotic approach. In our experience, robotic surgery in morbidly obese patients is associated with better quality staging of endometrial cancer. With a comprehensive approach, a professional bedside assistant, use of a monopolar cautery hook, and our protocol of treating morbidly obese patients, robotic surgeries can be safely performed in the vast majority of patients with a BMI of 40 kg/m² or greater, with lymph node counts being similar to nonobese patients, and with conversions to laparotomy reduced to a minimum.

Key Words: Robotic lymphadenectomy, Morbidly obese, BMI greater than 40, Endometrial cancer, High volume

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*St. Vincent Gynecologic Oncology, †Department of Obstetrics and Gynecology, ‡Office of Research & Clinical Trials, and §Northside Anesthesia Services, St. Vincent Indianapolis Hospital, Indianapolis, IN. Address correspondence reprint requests to Hubert Fornalik, MD, Goshen Center for Cancer Care, 200 High Park Ave, Goshen, IN 46526. E-mail: hubert.fornalik@gmail.com.

Present address of H. Fornalik and N. Fornalik is Goshen Center for Cancer Care, Goshen, IN.

Present address of T. Zore is University of California at Los Angeles, CA.

Present address of G. Wright is Exeter Hospital, NH.

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The rate of morbid obesity (body mass index [BMI] ≥ 40 kg/m²) among American women in the 40 to 59 age group and 60 and older group is 9.8% and 6.8%, respectively, among all races combined, and 17.9% and 12.1%, respectively, among non-Hispanic blacks.¹

The comprehensive surgical staging of women with endometrial cancer is controversial.² The Society of Gynecologic Oncology and the American College of Obstetricians and Gynecologists recommend comprehensive staging of women with endometrial cancer and adaptation of a minimally invasive approach.^{2,3}

The largest randomized study, the Gynecology Oncology Group (GOG) Lap2 study, randomly assigned 2616 women in 2:1 fashion to laparoscopy and laparotomy for comprehensive surgical staging.⁴ Considering such treatment allocation and 57% conversion rate among patients with BMI greater than 40 kg/m²,⁴ only 28% of patients in that cohort (approximately 72 women) underwent successful laparoscopy.⁵ The data from the study were presented as combined for the entire BMI of 40 kg/m² or greater group; thus, the outcomes of successful laparoscopies cannot be analyzed.

Although many studies use the terms *obese* and *morbidly obese* in their titles, only few studies separately report the results of endometrial cancer surgery in women with class III obesity (BMI ≥ 40). Few patients in those studies undergo comprehensive surgical staging with pelvic and paraaortic lymphadenectomy (Table 1). A database study from a Nationwide Inpatient Sample, including 1087 patients with BMI of 40 kg/m² or greater, undergoing surgery in 2011, reported some form of lymphadenectomy among 34% of patients undergoing laparotomy, 30% of those undergoing robotic surgeries, and 18% of laparoscopic cases.¹⁵ Currently, no analytic studies are comparing robotics with other surgical approaches in the BMI of 40 kg/m² or greater population undergoing staging of endometrial cancer.

MATERIALS AND METHODS

Approval from the institutional review board was obtained before data collection. All patients who underwent surgical staging for endometrial cancer by 2 gynecologic oncologists were identified between May 1, 2011, and June 30, 2014. A retrospective chart review was performed, and only those patients with a BMI of 40 kg/m² or greater (rounded to the nearest whole number) with a postoperative pathology consistent with the endometrioid-type of endometrial cancer were included in the study. Patients with type II endometrial cancers were not included in our study because they undergo a different type of robotic surgery with hand assistance at our institution to better assess the peritoneal surfaces.¹⁶ All patients were referred by outside physicians to 2 surgeons according to the referring

physician's preference. One surgeon performed laparotomy only for the surgical staging of endometrial cancer, whereas the other surgeon intended to perform only robotic surgeries. Patients did not cross between the surgeons, which reduced the selection bias. The surgeon performing robotic surgeries had performed more than 200 of them yearly, whereas the other surgeon had performed more than 250 laparotomies yearly. The physician who mainly performed robotic surgery performed 2 surgeries via laparotomy. One patient underwent laparotomy because of the large size of her uterus and the second because of the presence of ascites and the suspicion of peritoneal carcinomatosis. All robotic cases had an experienced physician assistant (PA) as the bedside assistant, and almost all cases had a resident involved. Third- and fourth-year residents worked via the teaching console, and second-year residents worked as bedside assistants during the hysterectomy portion of the case. Every robotic case was performed in the 40-degree Trendelenburg position using the da Vinci Si Surgical System (Intuitive Surgical, Sunnydale, Calif) and Titan surgical table (Trumpf Medical Systems, Inc, Saalfeld, Germany). All laparotomy cases were performed with a resident acting as a first assistant or, rarely, a PA if no resident was available. Surgical staging adhered to guidelines described in the *Gynecologic Oncology Group Surgical Procedures Manual*.¹⁷ The decision to perform complete staging and inframesenteric (below inferior mesenteric artery) paraaortic lymph node sampling was at each surgeon's discretion; however, it was the intent to perform comprehensive surgical staging whenever feasible. All patients scheduled for robotic surgery were managed according to our approach to treating morbidly obese patients, as described in Table 2. Patients with grade 2 and 3 tumors underwent a computed tomography scan of the abdomen and pelvis preoperatively. In cases of peritoneal carcinomatosis, patients were considered for debulking surgery and were not included in the study.

All inpatient and outpatient charts of the eligible patients were reviewed. Demographics and surgical and postoperative data, including complications within 90 days of surgery, were collected.

Statistical analyses were performed using SPSS 22 software (IBM Corp, released 2013, version 22.0, Armonk, NY). The Mann-Whitney *U* test was used to analyze continuous variables because of their nonparametric nature, and the χ^2 test and Fisher exact test were used to compare categorical data. We compared the number of lymph nodes removed during pelvic and paraaortic lymph node dissection in each surgery group when BMI was used as a continuous variable using a Poisson regression. *P* values less than 0.05 were considered statistically significant.

Literature review was performed by one of the authors (HF) using PubMed database. Records from 1966 to August 2016, presented in the English language, were searched using

TABLE 1. Studies on MIS in endometrial cancer patients with BMI ≥ 40

Author	Sizes of Cohorts of Patients With BMI ≥ 40 Undergoing MIS, (N = Size of Entire BMI ≥ 40 Cohort)	No. MIS Patients Per Year*	Mode of Surgery	Mean/Median BMI	Operating Room Time (min)	Operative Time (min)	Assistant	Pelvic LND (%)†	Median no. Paraortic LN	Paraortic LND (%)‡	Median no. Paraortic LN	Complications (%)	Readmission (%)	Death (%)	Conversions (%)
Pavelka et al (2004) ⁶	Laparotomy, N=75, 13 per year	0	X	—	—	205‡	—	81‡	18‡	59‡	6‡	56‡	—	1.3	—
Ginderson et al ⁵	GOG Lap2 data: MIS ~ 167, N=261§	1‡	XL	—	—	—	—	99§	18§	90§	5§	33§	10§	0.8	57
O'Hanlan et al (2006) ⁷	MIS-12, N-12	1	L	—	—	185	—	100	21	100	—	17	—	0	—
O'Gorman (2009) ⁸	MIS-16, N-16	4	L	—	—	—	—	—	—	—	—	4	—	0	6
Lau et al (2011) ⁹	MIS-23, N-23	12	R	46	—	257	—	100	11	50¶	5	17	—	0	0
Giugale et al (2012) ¹⁰	MIS-102, N-275 (BMI 40-49.9 cohort)	8	RL	44	—	193	—	37	13	1	2	18#	4#	—	19
Farthing et al (2012) ¹¹	MIS-41, N-123, (BMI ≥ 50 cohort)	3	RL	58	—	188	—	20	10	—	0	24#	5#	—	24
Stephan et al (2015) ¹²	MIS-53, N-53	9	L	—	—	75	—	3	—	—	—	23	—	0	2
Mendivil et al (2015) ¹³	MIS-56, N-56 (BMI ≥ 50 cohort)	9	R	56	360	260	RF	93	17	80	3	20	—	1.8	20
Letiao et al (2016) ¹⁴	MIS-16, N-53 (L cohort)	5	L	48	—	109	—	—	4	—	—	6	6	0	6
Averages of MIS studies:	MIS-13, N-53 (R cohort)	4	R	51	—	167	—	—	5	—	—	15	0	0	8
Fornalik et al (2018)	MIS-14, N-232, (1993-2007: L era)	1	L	45	—	191**	—	50	11	—	—	15**	—	0	12**
	MIS-111, N-194 (2008-2012 R era R 90)	22	RL	46	—	191**	—	73	9	—	—	15**	—	0	3**
	MIS-42	7	—	49	—	178	—	60	11	60	3	15	3	0	11
	Laparotomy cohort-55	11	X	44	166	126	R	89	19	60	4	29	6	0	—
	Robotic cohort-76	24	R	47	260	203	PA	96	22	75	9	22	8	0	0

Studies listed in italics were benchmark studies provided for comparison to studies using minimally invasive surgeries. Only studies reporting outcomes on BMI ≥ 40 kg/m² cohorts are included. Presented data refer to MIS cohorts only except for the Pavelka et al study and laparotomy cohort from our study presented here for comparison. *Averages of MIS studies; †don't include GOG Lap2 study because in reported BMI ≥ 40 kg/m² cohort, approximately 72% of patients ended up having laparotomy (effect of 2:1 randomization and conversions). ‡Mean number of MIS endometrial cancer cases with BMI ≥ 40 kg/m² per year per institution. †Percentage of patients undergoing successful lymphadenectomy out of cases when it was thought to be indicated, as per treating surgeon. ‡This study describes patients who had surgeries performed by laparotomy only. Data presented for comparison with MIS cases. §Data from GOG Lap2 study that accrued patients between 1996 and 2005. More than 29 institutions were participating. Results of BMI40 cohort were reported as a summary of results for patients undergoing laparotomy and laparoscopy. Separate results for patients undergoing successful laparoscopy are not available. Considering 64% of patients being randomized to laparoscopy, and 57% conversion rate, BMI40 cohort is estimated to include approximately 72 patients who underwent successful laparoscopy (ie, 28%). The protocol of this prospective randomized study required pelvic and paraortic lymphadenectomy to be performed in all patients. ||In this study, mean operative time was 185 minutes for patients undergoing LND (total of 27 patients across all BMI categories) and 146 minutes for BMI ≥ 40 kg/m² patients (4 of 12 morbidly obese patients were felt to meet criteria and successfully underwent LND). ¶Paraortic lymphadenectomy was thought to be indicated in 2 patients with BMI ≥ 40 kg/m². One patient underwent that procedure. #In this study, total number of complications and readmissions for the BMI ≥ 40 kg/m² and BMI ≥ 50 kg/m² groups was reported as 0.9 and 1.21 (per patient), respectively, and not presented separately for patients who underwent MIS. For the entire study group (BMI ≥ 30 kg/m²), risk of complications with MIS is 0.2 (odds ratio) compared with the 30 < BMI < 40 kg/m² group. Frequency of readmission was reported as 8.2% and 10.9% for BMI ≥ 40 kg/m² and BMI ≥ 50 kg/m² groups, respectively. Chances of readmission among the MIS group were 0.47 (odds ratio) compared with the laparotomy group. This calculation probably underestimates MIS complication rate in the BMI ≥ 40 kg/m² and BMI ≥ 50 kg/m² groups. **Conversion rate is reported to be 12% for all MIS cases, including those performed during "robotic era"; † conversion rate for robotic cases; no routine lymphadenectomy before 2000, 2000-2005 routine lymphadenectomy, since 2005, 55% of patients underwent sentinel lymph nodes mapping and selective lymph nodes sampling. The LN count is provided for the entire group during given time frame, including laparotomy patients. Authors provide surgery time and complication rate as average for the entire MIS group. L, laparoscopy; LN, lymph nodes; LND, lymphadenectomy; N, total number of cases in the study; R, robotic; RF, residents & fellows; and X, laparotomy.

TABLE 2. Surgical protocol and technique for robotic comprehensive staging of morbidly obese patients**Preoperative approach:**

- Dedicated team proud of taking care of complicated patients
- Internal Medicine consultation
- Anesthesia consultation for BMI > 50
- Multidisciplinary subspecialty consultations at our institution
- Optimization of chronic conditions before surgery (<0.5% considered not fit)
- Bowel prep with 2 d of clear liquids before surgery to improve exposure
- CT scan of abdomen and pelvis for grade 2 and 3 tumors
- Close cooperation with Anesthesia Department:
 - Encouraging anesthesiologists to follow up postoperatively on most difficult patients and providing verbal feedback on outcomes
 - Requesting 1 of 2 expert anesthesiologists for cases with BMI > 60 or chronic respiratory or heart failure
 - Open discussion of outcomes with Anesthesia
 - Anesthesia champion for robotic surgeries reports to the rest of the Anesthesia group

Intraoperative approach:

- Residents perform/assist with benign part of the procedure
- Gynecologic Oncology physician assistants assists with lymphadenectomy
- Positioning by dedicated room staff verified by Medical Doctor (MD positions for BMI > 60.)
- Availability of bed leg extensions for patients not fitting bariatric stirrups
- 40 degrees Trendelenburg position—Titan surgical table
- Docking robot in supine position either between the legs or across abdomen for extensive lysis of adhesions
- Morcellation of large specimen inside the vagina in retrieval bag
- If vaginal removal of specimen is not feasible, the specimen is removed via upper abdomen vertical incision, similar to hand-assisted robotic surgeries
- Lymphadenectomy performed at the beginning of surgery, when relaxation is optimal
- Extraperitoneal lymphadenectomy for patients unable to tolerate Trendelenburg position or if enlarged lymph nodes can't be reached via transperitoneal approach
- Hysterectomy performed first for patients at high risk of not tolerating surgery
- Bladder insufflation with CO₂, from sterile field, for difficult bladder dissection

Anesthesia approach:

- Consideration for larger endotracheal tube size
- Two large IV accesses
- IV fluids: goal of less than 1500 mL while in Trendelenburg position
- Maximal intraairway pressure adjusted to BMI and body habitus
- Goal of Tidal Volume \geq 450 mL
- Decreasing insufflation pressure (starting at 15 mm Hg) but not level of Trendelenburg for difficulty with ventilation
- Customizing ventilation settings to individual patient
- Pressure control ventilation-volume guaranteed mode increases tidal volume by 20%
- Higher PEEP (Positive end-expiratory pressure)
- Adjusting paralysis at early signs of muscle spasm (typically detected before indicated by nerve stimulation)
- Low threshold to use short course of Bi-Pap immediately after extubation
- Overnight mechanical ventilation for patients at high risk of laryngeal edema or respiratory failure

Surgical technique:

- Monopolar cautery hook: cautery activated after lifting tissue 1 mm off of vessel
- 30-degree 12 mm camera
- First trocar entry via assistant's trocar site located 2 fingerbreadths below left costal margin
- Five-blade laparoscopic fan for difficult exposure
- Paddle retractor or second fan via second assistant trocar for the most challenging cases
- Grasping retractor with suture net in third arm if additional retraction needed
- Flipping small bowel mesentery
- Packing mesentery with 4 × 4 gauze
- Packing lymphadenectomy spaces with Codman's surgical straps to increase distance to the ureter and improve hemostasis
- Suturing sigmoid epiploica to pelvic sidewall to improve exposure
- Creating tent from mesentery for retraction around paraaortic region
- Usage of third robotic arm from the left side
- Dissection of left paraaortic lymph nodes by crossing aorta from the right side
- Preservation of sympathetic nerves via preservation of mesentery over left common iliac vessels
- En block lymph nodes resection
- Hemostatic agent and 5–0 Prolene suture readily available for paraaortic lymphadenectomy
- Robotic suturing of perforator and vascular injuries

The first bolded line represents average results from the previously listed 8 eligible studies. The second bolded line represents results of our robotic cohort.

Bi-Pap, bilevel positive airway pressure; IV, intravenous.

TABLE 3. Demographics and operative data

	Robotic	Laparotomy	<i>P</i>
	<i>n</i> = 76 (%) [IQR]	<i>n</i> = 35 (%) [IQR]	
Age (y)	61 [12]	62 [9]	0.63
BMI (kg/m ²)	47 [11]	44 [6]	0.13
Race			0.21
White	71 (94.7)	30 (85.7)	
Black	3 (4)	3 (8.6)	
Hispanic	0	1 (2.9)	
Other	1 (0.9)	1 (2.9)	
Comorbidities ≥ 4	35 (46.1)	13 (38.2)	0.53
EBL (mL)	150 [150]	500 [450]	<0.001
Complications:			
Intraoperative	7%	0%	0.18
Postoperative	15%	29%	0.12
Wound	1.3%	3%	0.59
LOS (d)	1 [1]	5 [3]	<0.001
Total surgery time	203 [69]	126 [35]	<0.001
Total room time	260 [76]	166 [35]	<0.001
Lymph nodes			
Pelvic dissection performed	73 (96.1)	31 (88.6)	0.20
Paraaortic dissection performed	57 (75)	21 (60)	0.12
Pelvic LN (median)	22 [15]	19 [11]	0.11
Paraaortic LN (median)	9 [12]	4 [10]	0.09
Stage ≥ III	8 (10.5)	7 (20)	0.23
Stage IIIA/IIIB	3 (3.9)	3 (8.6)	0.38
Stage IIIC1	4 (5.2)	2 (5.7)	1
Stage IIIC2	1 (1.3)	2 (5.7)	0.23

BMI, body mass index; EBL, estimated blood loss, IQR, interquartile range; LN, lymph nodes; LOS, length of stay.

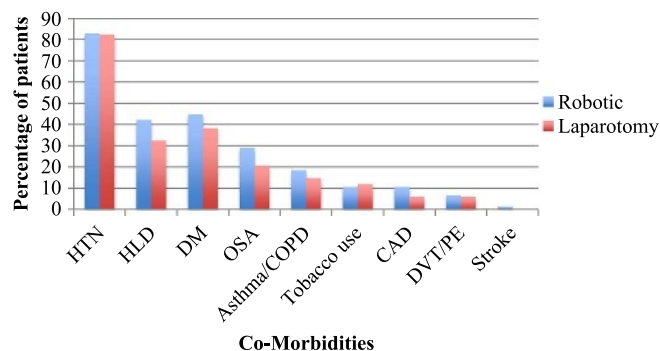
the following terms: *morbid obesity, endometrial cancer, robotic, laparoscopic, and surgery*. Studies that have not separately reported outcomes of patients with BMI of 40 kg/m² or greater were excluded.

RESULTS

There was no statistically significant difference between the groups in terms of demographics and incidence of stage III (Table 3). In general, both groups of women had a high percentage of having 4 or more comorbidities, including morbid obesity (46.1% in the robotics group and 38.2% in the laparotomy group; *P* = 0.53). There was no difference in the frequency of comorbidities in either group (Fig. 1).

Six intraoperative complications occurred in 5 patients in the robotics group, and no intraoperative complications occurred in the laparotomy group. Three superficial, nonpenetrating bladder injuries were repaired robotically without further consequences. One of the patients who had a bladder injury also had a superficial injury to the internal iliac artery, which was repaired robotically. This patient required 3 units of blood intraoperatively and 2 liters of albumin. She remained intubated postoperatively and required a 3-day stay in the intensive care unit (ICU) and was discharged home on postoperative day 4. Another patient had a small superficial injury to the distal external iliac artery and required a figure-of-eight 5–0 Prolene suture for repair. This did not result in any visible vessel narrowing or long-term consequences. The patient was discharged home on postoperative day 2. The fifth patient, at the end of the procedure, when she was being transferred onto a hospital bed, developed ventricular tachycardia followed by cardiac arrest. She was coded and resuscitated after approximately 10 minutes. The patient had a known history of atrial fibrillation and hypertension. She was transferred to the ICU, where she eventually underwent a tracheostomy and was weaned off the ventilator. She was discharged to a skilled nursing facility on postoperative day 29. This event was likely directly related to the chronic toxicity of her cardiac medication and not to the surgical care.

Poisson regression analysis, using BMI as a continuous variable, revealed that as BMI increased by 1 unit, the number of



HTN=hypertension, HLD=hyperlipidemia, DM=diabetes mellitus, COPD=chronic obstructive pulmonary disease, CAD=coronary artery disease, DVT=deep vein thrombosis, PE=pulmonary embolism

FIGURE 1. Percentage of patients with comorbidities. CAD indicates coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; DVT, deep vein thrombosis; HLD, hyperlipidemia; HTN, hypertension; and PE, pulmonary embolism.

pelvic lymph nodes removed was higher by 5% in the robotic group compared with that in the laparotomy group ($P < 0.001$). Moreover, as the BMI increased by 1 unit, the number of paraaortic lymph nodes removed increased by 12% in the robotic group compared with that in the laparotomy group ($P < 0.001$).

The overall incidence of postoperative complications was 14.5% in the robotic group and 28.6% in the laparotomy group ($P = 0.12$). There was a trend toward a higher risk of ileus or small bowel obstruction in the laparotomy group compared with the robotic group (11.4% vs 2.6%; $P = 0.08$). There was no difference in infectious complications between the groups (6.6% robotic vs 2.9% laparotomy; $P = 0.66$). The laparotomy group had a higher risk of acute respiratory failure requiring the patient to remain intubated postoperatively in the ICU than in the robotic group (14.3% vs 2.7%; $P = 0.03$). No cases of 90-day mortality occurred in either group. The hospital readmission rate was 7.9% in the robotic group versus 5.7% in the laparotomy group ($P = 1.00$). No conversions from robotic surgery to laparotomy occurred in either group.

DISCUSSION

This retrospective cohort study demonstrated that at a high-volume center with high-volume surgeons and a multidisciplinary approach, comprehensive surgical staging of morbidly obese patients can be performed with similar lymph node counts as in the general population, regardless of whether the laparotomy or the robotic approach is used. With increasing BMI, robotic surgery resulted in more lymph nodes being removed than in laparotomy ($P < 0.001$). Robotic surgery was also associated with less blood loss, shorter hospital stay, longer surgery time ($P < 0.001$), and a trend toward fewer complications than laparotomy (14.5% vs 28.6%; $P = 0.12$). Many studies on populations with lower BMI have demonstrated similar findings.^{18–21} Using our approach to anesthesia, outlined in Table 2, the risk of prolonged intubation and ICU admissions was lower with robotic surgery than with laparotomy (2.7% vs 14.3%; $P = 0.03$), which contradicts data from the University of Virginia and Duke University, where the rates were 6.2%, 0.8%, 0.6% for robotics, laparotomy, and laparoscopy, respectively, for patients with a mean BMI of 43 kg/m².¹⁰

Based on our review of the literature, this is currently the only analytic study that compares robotics with laparotomy for the surgical staging of endometrial cancer in a population with a BMI of 40 kg/m² or greater. Data from 9 studies that reported outcomes of cohorts of patients with BMI of 40 kg/m² or greater undergoing minimally invasive surgery (MIS) are listed in Table 1.^{5–14} Data from the benchmark laparotomy study of Pavelka et al⁶ are listed for comparison. Operative times vary significantly from 75 minutes reported by Farthing et al¹¹ to 260 minutes reported by Stephan et al.¹² In the first study, 3% of patients underwent pelvic lymphadenectomy, whereas in the second study, 93% of patients with BMI of 50 kg/m² or greater underwent pelvic lymphadenectomy and 80% paraaortic lymphadenectomy. Certainly, longer surgeries in the Trendelenburg position pose unique anesthesia challenges. In our opinion, these can be successfully overcome with skill, determination, experience, and repetition. Similar to our study, Stephan et al¹² stated that no anesthesia-related conversions to laparotomy occurred. Details of our management of anesthesia, Trendelenburg position, and our surgical protocol will be reported separately.

The lymph node count reported in our robotic cohort is similar to that reported from a study on the comprehensive staging of high-grade endometrial cancer from 6 high-volume institutions.²² Among patients undergoing MIS with a mean BMI of 30 kg/m², the pelvic lymph node count was 24 versus 22 in the robotic group reported here. There was a difference in paraaortic lymph node count, 15 versus 9, because 42% of patients in that study underwent paraaortic lymphadenectomy above the inferior mesenteric artery level. Out of the reported MIS BMI of 40 kg/m² or greater cohorts (Table 1), only this robotic cohort and the GOG Lap2 cohort, with 72% of patients ending up with laparotomy, had a median greater than 4 paraaortic lymph nodes harvested, which was established as an adequate lymphadenectomy in the benchmark paper by Seamon et al²³ on patients with BMI of 30 kg/m² or greater. Other studies on patients with endometrial cancer have included patients with BMI of 40 kg/m² or greater, but those patients' outcomes cannot be analyzed because they have been mixed with data on patients with lower BMI. The GOG Lap2 study, which introduced laparoscopy to management of endometrial cancer, cannot alone serve as adequate scientific justification for a laparoscopic approach to comprehensive staging of patients with BMI of 40 kg/m² or greater because of a 57% conversion rate in that cohort.⁴

Our robotic cohort and the cohort published by Lau et al⁹ are the only ones that reported no conversions to laparotomy in their populations with BMI of 40 kg/m² or greater. The latter study described outcomes of 23 patients, of whom only 1 underwent paraaortic lymphadenectomy. Conversions are not only a measure of technical feasibility of the procedure, but also have financial impact. They are associated with 33% increased cost of surgery, as reported by Leitao et al,¹⁴ in this population. Bijen et al²⁴ concluded that laparoscopic hysterectomy was not cost-effective in the treatment of endometrial cancer in a population with BMI of 35 kg/m² or greater because of the 32% conversion rate.

Since the creation of the robotic program at the study institution, our team has adopted and developed 52 different adjustments, which are listed in Table 2. The impact of those adjustments has not been studied separately; thus, one cannot distinguish which are the most meaningful. In our opinion, the most critical modification was the multidisciplinary team approach with active involvement of the anesthesia team, use of PAs during the lymphadenectomy portion of the procedure, and use of a monopolar hook instrument. It is the opinion of the authors that because robotic surgeries in morbidly obese patients are the most challenging robotic cases from a surgical and anesthesia perspective, patients require a bedside assistant familiar with lymph node anatomy and proficient with assisting techniques to provide an efficient flow of surgery and optimal exposure. In 2006, O'Hanlan et al⁷ advocated "working with similarly trained colleagues as cosurgeons" to limit complications during advanced laparoscopic surgeries. For reasons of conversion listed in the GOG Lap2 study (57% poor exposure, 16% cancer spread, and 11% excessive bleeding), the majority could be addressed by better performance of the bedside assistant's job during robotic surgeries.⁴ Stephan et al,¹² in a BMI of 50 kg/m² or greater cohort, reported a 19.6% conversion rate, with all cases being attributed to the inability to perform a paraaortic lymphadenectomy because of inadequate visualization.

Considering the number of adjustments needed to complete the most challenging cases robotically, repetition is very important. It seems that out of published MIS studies on BMI of 40 kg/m² or greater cohorts, institutions on average were performing 7 hysterectomies per year in that population, with less than 60% of those being accompanied by lymphadenectomies (Table 1, columns 3, 9, & 11). Except for a study from The University of Iowa¹² and the GOG Lap2 study, our research found only 3 other studies that reported on 4,⁷ 1,¹⁰ and 1⁹ patient, respectively, undergoing paraaortic lymphadenectomy in a BMI of 40 kg/m² or greater population. Those numbers are also likely to be divided among few surgeons per institution, which further dilutes the experience and affects the learning curve.

Although the incidence of BMI of 40 kg/m² or greater varies among endometrial cancer populations, from 2.7% in Italy²⁵ to 22% in Ohio,⁶ the incidence of stage IIIC is similar in this population, at 8%.⁶ Considering further developments in robotic and laparoscopic surgery and our conversion and complication rate, we think that the risk-benefit of comprehensive staging is more in favor than reported in the GOG Lap2 BMI of 40 kg/m² or greater cohort analysis.⁵ Such an approach is further justified by our rate of stage IIIC being 8.1% among “all comers” with endometrioid subtype versus 3.8% in the GOG Lap2 study, which, as stated by the authors, was subject to “substantial selection bias” due to enrollment in a clinical trial.⁵

A novel approach to lymphadenectomy with sentinel lymph nodes mapping does not change the need for comprehensive lymphadenectomy skills because the dissection of all nodal regions is advocated to search for enlarged lymph nodes, despite the mapping status.²⁶ This was recently reinforced by Society of Gynecologic Oncology consensus recommendations.²⁷ Bilateral detection of sentinel lymph nodes is 60%, but some studies suggest it is 30% in morbidly obese patients (abstract²⁸). That would call for a comprehensive lymphadenectomy, at least unilaterally, in 70% of patients at risk for lymph node metastasis with a BMI of 40 kg/m² or greater.

This study’s major strengths are the inclusion of only morbidly obese women with a BMI of 40 kg/m² or greater and the reduction of selection bias by patients being offered either laparotomy or robotic surgery — but not both. Assigning patients to 2 different surgeons practicing within the same practice, based on a natural referral pattern, contributed to a more even distribution of risk factors. The selection of the mode of surgery was not based on patients’ characteristics, but on each physician’s approach applied to all their patients. This study’s major weaknesses are its retrospective nature and its single-surgeon experience, which may not be generalizable to other surgeons and centers. Both surgeons had an approach of comprehensive surgical staging of patients with endometrial cancer. However, a different physician managed each group of patients with inherent differences in clinical decision-making patterns and documentation. Lastly, because the size of study cohorts was limited by number of available cases, the study might be prone to type II statistical error, and not detect statistically meaningful differences when those in fact exist.

CONCLUSIONS

This study reports on one of the largest cohorts of patients with BMI of 40 kg/m² or greater undergoing successful

comprehensive surgical staging of endometrial cancer via MIS. Robotic surgery, in our settings, was associated with better quality of staging than the laparotomy group, but with 56% longer surgeries (operating room time: 260 vs 166 minutes, $P < 0.001$; range 171–637 vs 138–311 minutes). Furthermore, the results of our study challenge the common belief by suggesting that complicated patients undergoing longer MIS procedures in Trendelenburg position, overall, tolerate the procedure better than those undergoing a *quick* laparotomy.

The authors are skeptical that similar results can be achieved in a low-volume practice even for very skillful surgeons. Ultimately, the cornerstone of the reported success is a teamwork approach with many professionals having adequate repetition to troubleshoot complex and overlapping problems and to implement remedial strategies. Referrals to high-volume centers specializing in robotic surgeries in morbidly obese patients should be considered among low-volume institutions. Consideration should be given to channeling high-risk surgeries to certain surgeons within practices and departments to improve outcomes through greater repetition.

Ideally, a prospective randomized study with a larger sample size and long-term follow-up would provide the ultimate validation of our approach.

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