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ORIGINAL ARTICLE

Body mass index, conversion rate and complications among patients undergoing robotic surgery for endometrial carcinoma

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Abstract A retrospective cohort study was performed to evaluate the relationship of BMI to conversion rate in patients undergoing robotic surgery for endometrial cancer. Secondary outcomes were operative times, number of lymph nodes retrieved, and complications. Women with endometrial cancer scheduled for robotic surgery from September 2008 to September 2012 were included. Women were divided into three groups based on BMI, and conversion rates to laparotomy were compared. Descriptive and comparative analyses were performed among non-obese, obese, and morbidly obese women who completed robotic surgery. 298 women were scheduled for robotic surgery for endometrial carcinoma: 87 non-obese (BMI 19–29, μ 25.23), 110 obese (BMI 30–39, μ 34.21), and 101 morbidly obese (BMI 40–71, μ 47.38). Conversion to laparotomy occurred in 18 patients (6%), with no difference in conversion rate between BMI categories. Direct comparison between converted and completed robotic patients showed no significant differences in preoperative characteristics, except that patients who required conversion had a higher number of previous abdominal surgeries. Patients completing robotic surgery underwent node dissections at similar rates in all three BMI categories. Operating room time, but not surgical time, was increased in morbidly obese patients. There were no significant differences in complications, performance of lymphadenectomy, or lymph node yields between BMI categories. Increase in BMI was not associated with an increase in rate of conversion to laparotomy or complication rate in patients undergoing robotic surgery for endometrial carcinoma. Node dissections were pathologically equivalent between BMI categories.

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Introduction

Obesity affects more than one-third of adults in the United States with prevalence related to both age and gender. Ogden reported obesity (BMI $\geq$30) in 34.9 % of adults over age 20 in 2011–2012 in the United States. The prevalence increased to 39.5 % in adults between ages 40–59 and 35.4 % in adults age 60 and older. In addition there was a significant increase in prevalence of obesity in women over age 60 from 31.5 % in 2003–2004 to 38.1 % in 2011–2012, $p = 0.006$. [1] This is of particular concern given the increased risk of endometrial cancer associated with obesity. In the Women's Health Initiative study of over 87,000 women the incidence of endometrial cancer was 187.1 cases per 100,000 person-years in women with BMI >30 versus 107.3 cases per 100,000 person-years for women with BMI <25 ($p < 0.0001$). Obesity was an independent risk factor for the development of endometrial cancer. [2] In Renehan's systematic review and meta-analysis of the effect of obesity on cancer risk, endometrial cancer was ranked highest among obesity-associated cancers in women. [3]

Initial treatment of endometrial cancer is surgical, and the advantages of minimally invasive surgery over laparotomy for treatment of endometrial carcinoma have been clearly demonstrated. The Gynecologic Oncology Group LAP2 trial is the largest prospective trial of laparoscopy versus laparotomy for surgical staging of endometrial cancer. Findings included reduction in blood loss, length of stay, wound complications, and time to return to normal activities for patients undergoing laparoscopy with no significant changes in recurrence rates or overall survival when compared with laparotomy. [4] Unfortunately the rate of conversion from laparoscopy to laparotomy was proportional to body mass index (BMI), with an increase from 17.5 % in BMI of 25 to 57.1 % in BMI >40. [5] Robotic surgery provides a stable platform, three-dimensional view, and wristed instruments, improving the ability to perform complex minimally invasive procedures. These features may allow successful completion of minimally invasive surgery for obese patients with endometrial carcinoma.

The purpose of the current study was to examine the effect of BMI on the rate of conversion to laparotomy among patients scheduled for robotic laparoscopic surgery for endometrial carcinoma. A secondary objective was to compare surgical outcomes, including operative times, number of lymph nodes retrieved, and complications among BMI groups in patients who completed robotic surgery. This was a retrospective study, however, during this time patients were not excluded from robotic surgery consideration solely because of weight.

Materials and methods

This is a retrospective cohort study of women who were scheduled for robotic surgery from September 2008 to September 2012 at Crouse Hospital with a primary diagnosis of carcinoma of the uterus. This study was approved by the Institutional Review Board of Crouse Hospital. The case list was generated from surgical registrar records by scheduled procedure type and diagnosis code. The gynecologic oncology robotic program at Crouse Hospital was established in August 2008 with two board certified gynecologic oncologists (MJC and WDB), each with over 2 years of robotic surgery experience prior to the study period.

Patients were included if they were scheduled for robotic surgery with a preoperative diagnosis of uterine carcinoma. The decision to schedule robotic surgery was at the discretion of the gynecologic oncologist. During this time patients were not excluded from robotic surgery because of obesity. Pelvic ultrasound was not uniformly obtained on all patients, though many patients had ultrasound during their evaluation for abnormal bleeding. Prior to draping, a Trendelenburg test was performed in all patients; no patients were excluded based on Trendelenburg test. The da Vinci Si Surgical System was used with either three or four arms depending on physician preference. One additional 12 mm port was placed for use by the surgical assistant. A Vcare uterine manipulator (Conmed, Utica, NY) was placed prior to beginning the laparoscopic portion of the surgery in each case. The primary surgeon was a board certified gynecologic oncologist and the assistant was a trained physician's assistant. Data were collected from inpatient and outpatient records and included demographics, medical history, preoperative pathology and imaging, surgical procedures and times, surgical pathology and complications. Follow-up data were collected for 30 days postoperatively.

Height and weight were obtained preoperatively in all patients. Body Mass Index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters (kg/m^2). Obesity categories were based on the World Health Organization (WHO) International Classification of adult obesity. [6] WHO obesity classes one and two were combined to form the group labeled "obese" with BMI 30–39.9. Morbid obesity was defined as BMI ≥40 (WHO class 3 obesity).

The primary end point was conversion to laparotomy. Conversion to laparotomy included any incision into the peritoneal cavity other than those required for port placement, including incision for delivery of the specimen. All patients underwent extrafascial hysterectomy with or without bilateral salpingoophorectomy. The decision to perform pelvic and/or para-aortic lymphadenectomy was made at the surgeon's discretion based on frozen section assessment of grade and depth of invasion. In general pelvic lymphadenectomy was performed on all patients with myometrial invasion while para-aortic lymphadenectomy was added for patients with >50 % myometrial invasion, with extent of dissection to at least the inferior mesenteric artery. Potential factors contributing to risk of conversion were examined, including patient factors (BMI, prior vaginal deliveries, and prior abdominal surgeries), uterine factors (size and weight), and tumor characteristics (grade, depth of invasion, and metastatic disease).

Secondary objectives were surgical outcomes including operative times, lymph node yields, and complications. Operative times were divided into surgical and non-operative room times. Surgical time included time from initial incision to closure. Non-operative room time included time for moving the patient onto the operating room table, positioning, induction of anesthesia, prepping and draping prior to the start of surgery as well as emergence from anesthesia, and moving the patient after the surgery. Patients who required conversion to laparotomy were excluded from secondary analysis. Lymph node performance and yields were stratified by BMI to assess adequacy of surgical procedures. Stage was assigned according to definitions of the 2009 FIGO staging system.

Comparisons between non-obese, obese, and morbidly obese patients were executed for pre-, intra-, and post-operative variables. Data for continuous variables are expressed as a mean and range, with appropriate one-way ANOVA or Fischer's exact tests comparing patients stratified by BMI; comparisons between robotic surgery and laparotomy data are examined using independent samples *t* tests. Categorical data are expressed as count and rate of incidence with associated Chi square comparisons. Significance level was set at $p < 0.05$.

Results

A total of 301 robotic surgeries for cancer of the uterus were scheduled during the study period. 3 cases were duplicates because of scheduling changes, resulting in a total of 298 patients who were scheduled for robotic surgery from September 2008 to September 2012 at Crouse Hospital with a primary diagnosis of carcinoma of the uterus. There were 87 non-obese, 110 obese, and 101 morbidly obese patients. The mean BMI was 36.05 (range 19–71). Patients who were morbidly obese were younger with more comorbidities, fewer vaginal deliveries, and larger uteri. There was no significant difference in preoperative tumor grade between BMI categories (Table 1).

Conversion from laparoscopy to laparotomy occurred in 18 patients (6 %). With the exception of the number of previous abdominal surgeries, there were no significant differences in the preoperative characteristics when comparing patients who underwent robotic surgery and those who were converted to laparotomy (Table 2). There was no difference in conversion rates between BMI groups. Laparotomy was performed in six non-obese, four obese, and eight morbidly obese patients. The most common reason for laparotomy was extensive adhesions in eight patients. One of those patients could not be insufflated due to inability to access the peritoneal cavity with standard laparoscopic techniques. Other reasons included metastatic disease in five patients, poor visualization in four patients, and unexpected large fibroids in one patient. There were no conversions for inability to ventilate. The decision for laparotomy was made prior to docking the robot in 11 cases. In one patient the decision for laparotomy occurred after completion of hysterectomy and bilateral pelvic lymphadenectomy due to inability to obtain adequate visualization for para-aortic lymphadenectomy.

Robotic surgery was completed in 280 patients (Table 3). There was no significant difference in surgical time between BMI groups. There is a significant relationship between BMI and non-operative room time, resulting in significantly longer overall operating room times.

Table 1 Preoperative characteristics by BMI category

	Non-obese ($N = 87$)	Obese ($N = 110$)	Morbidly obese ($N = 101$)	*p* value
BMI, kg/m2				
Mean	25.23	34.21	47.38	0.000++
Range	19–29	30–39	40–71	
Age, years				
Mean	64.38	64.20	59.86	0.002++
Range	36–92	34–90	32–79	
Uterine diameter*, cm	6.99	7.85	8.40	0.002++
Vaginal deliveries	1.95	1.76	1.34	0.027++
Abdominal surgeries	0.95	0.97	1.00	ns++
	# Patients (%)	# Patients (%)	# Patients (%)	*p* value
Preop FIGO grade				
1	51 (62.96)	63 (59.43)	58 (61.05)	ns+
2	20 (24.69)	31 (29.25)	33 (34.74)	ns+
3	10 (12.35)	12 (11.32)	4 (4.21)	ns+
Hypertension	39 (44.83)	55 (50.00)	65 (8.40)	0.019+
Diabetes	11 (12.64)	29 (26.36)	32 (64.36)	0.008+
Hypercholesterolemia	21 (24.14)	30 (27.27)	35 (31.68)	0.019+
Heart disease	4 (4.6)	11 (10.00)	8 (34.65)	ns+

* Diameter as measured on preop ultrasound

+ *p* value as determined by χ^2

++ *p* value as determined by one-way ANOVA

Table 2 Preoperative characteristics for completed robotic surgery versus conversion to laparotomy

	Robotic (n = 280)	Converted (n = 18)	*p* value
Age at surgery (average)	62.75	62.61	ns++
Vaginal deliveries (#)	1.66	1.94	ns++
Previous abdominal surgeries (#)	0.92	2.00	0.000++
	# Patients (%)	# Patients (%)	*p* value
BMI category			
Non-obese	81 (28.93)	6 (33.33)	ns+
Obese	106 (37.86)	4 (22.22)	ns+
Super obese	93 (33.21)	8 (44.44)	ns+
Preoperative FIGO Grade			
1	164 (62.12)	8 (44.44)	ns+
2	77 (29.17)	7 (38.89)	ns+
3	23 (8.71)	3 (16.67)	ns+
Preexisting comorbidities			
Hypertension	148 (52.86)	11 (61.11)	ns+
Diabetes	66 (23.57)	6 (33.33)	ns+
Hypercholesterolemia	81 (28.93)	5 (27.78)	ns+
Heart disease	23 (8.21)	0 (0.00)	ns+

\+ *p* value as determined by χ^2

++ *p* value as determined by *t* test

Table 3 Completed robotic surgery by BMI category: intra and postoperative data

	Non-obese (*N* = 81)	Obese (*N* = 106)	Morbidly obese (*N* = 93)	*p* value
Operative time, min	118.41	119.14	129.60	ns++
Room time, min	164.98	163.12	182.97	ns++
Nonoperative room time, min	46.57	43.99	53.30	<0.001++
Uterine weight, gm	87.59	103.53	131.50	<0.001++
Uterine diameter, cm	6.85	7.66	8.50	<0.001++
Pelvic node dissection performed, *N* (%)	70 (86.42 %)	100 (94.34 %)	78 (83.87 %)	ns+
Pelvic & paraaortic node dissection performed, *N* (%)	11 (13.58 %)	18 (16.98 %)	12 (12.90 %)	ns+
Pelvic nodes sampled, mean (range)	24.56 (10–54)	22.93 (6–49)	22.36 (3–44)	ns+
Paraaortic nodes sampled, mean (range)	10.64 (3–21)	8.50 (1–17)	7.75 (3–13)	ns+
Intraoperative complications	0	1	1	ns+++
Length of stay, days	1.16	1.03	1.08	ns++
Readmission within 30 days, *N* (%)	1 (1.23)	5 (4.72)	0 (0)	ns+++
Reoperation within 30 days, *N* (%)	0 (0)	2 (1.89)	0 (0)	ns+++

\+ *p* value as determined by χ^2

++ *p* value as determined by one-way ANOVA

+++ *p* value as determined by Fischer's exact test

Morbidly obese patients were not less likely to undergo pelvic or para-aortic node dissection. The decrease in hemoglobin from preoperative to post operative levels was statistically higher in patients with lower BMI, but the absolute difference was small. There was no difference in length of stay.

Complications were uncommon and were comparable across BMI categories. Two patients had intraoperative complications: one cystotomy and one vaginal laceration. Reoperation occurred in two patients. One patient (BMI 32) had a small bowel obstruction due to an incarcerated hernia at a port site that was reduced laparoscopically. One patient (BMI 31) had a sigmoid perforation that required laparotomy and diverting ileostomy. Readmission for fever was required in four additional patients, one of whom had a pelvic abscess. There were 15 minor complications in 14 patients including minor surgical site infection (four), urinary tract infection (four), vaginal bleeding/drainage (three), wound seroma (two), urinary retention (one), and lymphedema (one).

Morbidly obese patients were less likely to have aggressive tumors on final pathology as evidenced by trends toward lower rates of high grade tumors, deep myometrial invasion and lymph-vascular space invasion. However, pelvic node dissection and para-aortic node dissection were performed equally as often among the three groups. There was no difference in lymph node yields among BMI categories. Nodal metastases were uncommon. Seven patients (two non-obese, three obese and two morbidly obese) had pelvic node metastases in one to four nodes. The only para-aortic nodal metastasis occurred in a morbidly obese patient. There were no overall differences in stage distribution.

Discussion

The primary treatment for endometrial carcinoma usually begins with surgery, which is more challenging in obese patients. Given the association between endometrial cancer and obesity and the high rate of obesity nationwide it is important that surgical procedures for endometrial cancer are evaluated in the obese population. Standard laparoscopic surgery has been reported to be a feasible method of treating endometrial cancer, however it is less successful in obese patients. The Gynecologic Oncology Group LAP2 trial is the largest prospective trial of open versus laparoscopic surgery for endometrial cancer. It demonstrated the feasibility of comprehensive surgical staging for endometrial cancer with laparoscopy. The laparoscopic group showed equivalent intraoperative and reduced post-operative complications. [4] However, the patient population was relatively thin, with a median BMI of 29 in the laparoscopy group and 28 in the laparotomy group. Conversion rates were high and increased with BMI. Overall 25 % of patients required conversion to laparotomy. The conversion rate was 57.1 % in patients with BMI over 40, leading to concerns that minimally invasive surgery is not an optimal approach in larger patients. This is a significant limitation given the demographics of endometrial cancer. Pelvic and para-aortic lymphadenectomy was required in all patients on LAP2 though it was not performed in 8 % of patients in the laparoscopy arm. The success of lymphadenectomy in larger patients was not reported separately. Poor exposure was the most common reason for conversion from laparoscopy to laparotomy, accounting for 56.75 % of conversions. It is not noted whether the difficulty with exposure occurred during attempts at lymphadenectomy, but it is possible that less stringent requirements for lymphadenectomy would have resulted in lower conversion rates. Prior surgeon experience with minimally invasive surgery was not quantified in LAP2, however, comparison of institutions that accrued large numbers of patients versus institutions with lower accrual showed no difference in conversion rates. Since the study was open for patient accrual for 9 years it is likely that most surgeons were not early in the learning curve for the majority of the study.

Robotics allows a three-dimensional view with wristed instruments and scaled movement. The stable platform avoids the difficulty of maintaining instrument and camera position manually, especially in larger patients. These advantages have led to widespread adoption of the technology by gynecologic oncologists since its FDA approval for use in gynecologic surgery in 2005. There have been multiple reports of surgical management of endometrial carcinoma using robotics in an effort to improve the rate of successful completion of minimally invasive surgical staging. The first report of robotics for treatment of obese and morbidly obese women with endometrial cancer was published by Gehrig in 2008, and compared the surgical outcomes for 49 patients undergoing robotic versus 32 undergoing standard laparoscopic surgery. [7] Robotic surgery was associated with reduced operative time, blood loss, and length of stay. Lymph node yields were increased in the obese and equivalent in the morbidly obese groups undergoing robotic surgery. Since then larger series have compared robotic surgery to laparotomy for patients with endometrial cancer and BMI $\geq$30. [8–10] All have shown reductions in blood loss, overall complications, and length of hospital stay. When compared with laparotomy, robotic surgery resulted in equivalent lymph node yields in all series, and there were no differences in the number of patients undergoing lymphadenectomy. Surgical time was increased for the robotic approach, however. Rates of conversion to laparotomy were 10.9–15.6 %. There was no evaluation of the effect of BMI on the rate of conversion to laparotomy, but the rates overall were substantially improved over those reported in GOG LAP2.

There are few studies evaluating the effect of BMI on outcomes in patients undergoing robotic surgery for endometrial carcinoma. Endometrial carcinoma was the preoperative diagnosis in 127 of 257 patients undergoing robotic surgery in a series reported by Gallo. There was no difference in EBL, operative time, length of hospital stay or complications when comparing those with BMI <30 vs

30–40 versus ≥40 for the overall cohort. [11] A larger series of 364 women with endometrial carcinoma treated with robotic surgery were reported by Menderes. Mean BMI was 34.8 and outcomes were compared between BMI categories. While there were significant increases in EBL and length of stay related to increasing BMI, the absolute differences were small. Patients with BMI ≥50 had mean EBL of 152.7 versus 99.4 ml for patients with BMI <30, a statistically significant (p 0.002), but clinically insignificant difference. Likewise the length of stay was increased to 2.07 days in the largest patients compared with 1.39 days in the thinnest group (p 0.009). Longer operating room time, but not surgical time was reported for heavier patients. [12]

The major strength of our study is the mean BMI of 36.1, with over 70 % of patients in the obese or morbidly obese categories. This allows comparison between these groups and normal weight patients. Performance of lymphadenectomy and node counts was used as a reflection of the quality of the surgery. Neither was affected by BMI in our series. This supports the conclusion that minimally invasive surgery using robotics is a reasonable option in obese and morbidly obese patients with endometrial carcinoma. We confirmed the finding of longer operating room time with no difference in surgical time. This is reflective of the increase in time to move and properly position larger patients before and after surgery as well as an increase in time for induction and emergence from anesthesia. These factors are present regardless of the operative approach though positioning for minimally invasive surgery may take somewhat longer than for open procedures. Our definition of conversion was broad and included all patients who had abdominal incisions other than port sites. While some series do not include laparotomy for specimen retrieval in conversion rates, we believe that this is an inaccurate categorization. Obese and morbidly obese patients had larger uteri, but this did not appear to affect the conversion rate between BMI categories.

Because the study was retrospective, there is potential selection bias by the operating gynecologic oncologists. The high prevalence of obesity and morbid obesity in the series argues against any weight-based bias against offering robotic surgery. It is possible that selection was biased in favor of laparotomy for patients with higher grade tumors. This effect could be present at all weights or more often in larger patients, and is difficult to assess. Increased BMI was associated with more favorable histology in our study. This may not indicate selection bias, however since it has previously been reported that as BMI increases there is a decrease in depth of invasion, grade, presence of lymph-vascular space invasion, and non-endometrioid histology. [13] Another weakness is the lack of a standard prospective protocol for performance of surgical staging. The criteria for performance of pelvic and para-aortic lymphadenectomy are controversial at best, as are the definitions of adequate node excision. There was no statistically significant difference between weight categories in percentage of patients who had nodes excised, which suggests that there was not systematic bias against staging based on BMI. Finally, the possibility of type 2 statistical errors should be recognized. The power of our data to detect a 20 % difference in conversion rates is small, however, a 20 % difference (6 versus 7.2 %) is of no clinical significance. The data have 80 % power to detect a difference in conversion rates from 6 to 15 %, a more clinically useful parameter to both surgeons and patients. Using a one-way ANOVA pairwise method to test whether proportions between several groups are equal, the comparison of performance of pelvic and para-aortic node dissection between BMI categories is sufficiently powered (100 %).

The most important outcome for patients with endometrial cancer is the effect of robotic surgery on recurrence risk and overall survival, which was not addressed in the current study. When robotic surgery was compared retrospectively with standard laparoscopy there was no significant difference in survival (3-year survival 93.3 and 93.6 %), DFS (3-year DFS 83.3 and 88.4 %) or tumor recurrence (14.8 % and 12.1). [14] Outcomes from robotic surgery have also been shown to be comparable to those reported in the Surveillance Epidemiology and End Results database from the National Cancer Institute, with 88.7 % overall survival at 5 years. [15] It is unlikely that a randomized prospective comparison with open surgery will take place. Given the high conversion rates for standard laparoscopy in obese and morbidly obese patients a prospective comparison with robotic surgery also seems unlikely. Evaluation of robotics will more likely be based on longer follow-up from non-randomized cohorts. Our experience has shown that BMI should not be a deciding factor in the decision to offer robotic minimally invasive surgery to patients with endometrial cancer. In the future it will be important to evaluate recurrence patterns and survival data in patients who have undergone robotic surgery for endometrial cancer.

Compliance with ethical standards

Conflict of interest Dr. Cunningham discloses shares held of Intuitive Surgical. Dr. Dorzin has nothing to disclose. Dr. Nguyen has nothing to disclose. Ms. Anderson has nothing to disclose. Dr. Bunn has nothing to disclose.

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