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ORIGINAL ARTICLE

The impact of robotics on practice management of endometrial cancer: transitioning from traditional surgery

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Abstract

Background Evaluation of the impact of a new robotic surgery programme on perioperative outcomes for endometrial cancer

Methods A prospective database of all patients undergoing staging for endometrial cancer during July 2007–July 2008 was collected and analysed. Demographic data and perioperative outcomes were compared between cases performed via laparotomy, laparoscopy and robotics.

Results Sixty-five patients underwent staging during the time of data collection (LAP-26, LSC-7, ROB-32). No difference in surgical volume in the year before vs. after robotics was identified. Median operative time for robotics and laparotomy was significantly less than for laparoscopy ($p = 0.023$). There was no significant difference in lymph node yields between the three groups ($p = 0.92$). Robotics was associated with significantly less blood loss ($p < 0.0001$). Complication rates were significantly lower in the robotic group compared to the laparotomy group ($p = 0.05$). Median hospital stay was 1 day for the minimally invasive groups. Total number of perioperative inpatient days decreased from 331 to 150 in one year. Practice management of endometrial cancer transitioned from a predominantly open approach (5.6% LSC) to robotics (11% LSC, 49% ROB) within 12 months.

Conclusions Robotic surgery dramatically altered our management of endometrial cancer and was associated with a significant improvement in several perioperative outcomes when compared to laparotomy and laparoscopy. Copyright © 2009 John Wiley & Sons, Ltd.

Keywords robotic hysterectomy; emdometrial cancer; robotics; gynaecological oncology; minimally invasive surgery; da Vinci® surgical system

Introduction

The widespread utilization of minimally invasive surgical techniques has historically been limited in the field of gynaecological oncology. Early endometrial cancer staging as well as radical hysterectomy via traditional laparoscopy was first demonstrated to be feasible in the early 1990s (1–6). Benefits to minimally invasive surgery in the management of endometrial and cervical cancer include reduced blood loss, postoperative transfusion, postoperative pain, length of stay, recovery time and cost of treatment, with improved cosmesis (7–11). Tozzi *et al.* were the first to report similar disease-free and overall survival data from their prospective randomized

trial on endometrial cancer after a median 44 month follow-up (12). Since that time, others have reported their experiences with laparoscopic surgical management of early endometrial and cervical cancer (13–15).

Barriers to the widespread use of traditional laparoscopy in gynaecological oncology include a slow learning curve, the need for an experienced first assistant, difficulties with laparoscopic technology, difficulty of complex operations, limited mechanics of the human hand, exaggerated tremor, and lack of training during fellowship. Despite the well-delineated benefits of minimally invasive surgery, several surveys of members of the Society of Gynecolog Oncology reveal its under-utilization. In a 2005 survey, only 8% of gynecologist oncologists who responded to the survey reported utilizing laparoscopy for more than 50% of their patients, with endometrial cancer highlighting its under-utilization (16). Of note, only 25% of fellows surveyed reported feeling that they were getting good or very good laparoscopic training (17).

Minimally invasive techniques have expanded in the last 25 years to include robot-assisted laparoscopy. Robot-assisted laparoscopic techniques were first described by neurosurgeons who used the PUMA 560 for stereotactic manoeuvres in the brain under computed tomography guidance in 1988 (18). Since that time, robotics has been shown to have a role in urology, orthopaedics and cardiology (19–21). In April 2005 the da Vinci® surgical system was approved by the Food and Drug Administration for use in gynaecological procedures and was shown by to have a role in gynaecological procedures (22–26). This technique has been shown to be feasible in gynaecological oncology for early endometrial cancer staging procedures (27–30) as well as radical hysterectomies for early stage cervical tumours (31–33). Many of the barriers to use of traditional laparoscopy have been overcome using robotic surgical techniques. Limitations of the human hand are overcome by the seven degrees of movement and elimination of hand tremors that robotics offers. The robotic arms imitate the movements of the surgeon's hand, thereby removing the fulcrum effect of traditional laparoscopy. Visualization is improved with three-dimensional (3D) stereoscopic imaging. The operating surgeon requires little assistance from a first assistant and the learning process is accelerated, with a reported marked decline in operative time after 20 cases (34). Finally, robotics has been recently described in programmes affiliated with the training of gynaecological oncology fellows with no adverse impact on outcomes (35,36).

In this paper we detail the effect of a new robotic surgery programme on our practice management of endometrial cancer and describe the perioperative outcomes of our endometrial cancer staging surgeries via laparotomy (LAP), traditional laparoscopy (LSC) and robotics (ROB)

Materials and Methods

In June 2007, a dedicated robotic surgery programme was introduced at Northwestern University into the Division of Gynecologic Oncology, an ABOG-designated fellowship training programme. Robotics was introduced to expand surgical options for patients, serve as an educational tool for residents and fellows and allow minimally invasive performance of more complex procedures, such as a radical hysterectomy. The programme was initiated under the guidance of one gynaecological oncologist, who served as proctor for the four other gynaecological oncologists in the group after their company-sponsored training programme. For the purposes of orientation and training, an in-house porcine-based laboratory session was attended by all faculty and fellows-in-training in the Division of Gynecolog Oncology. This programme included instruction on patient positioning and trocar placement, docking of the robot, robotic instrumentation, performance of standard retroperitoneal dissection, and da Vinci system trouble shooting. Robotic surgeries were performed by four of the five members of the Division of Gynecologic Oncology and one clinical fellow. Three of five division members performed laparoscopic staging, and all five members performed traditional open staging procedures. The level of experience among division members for laparoscopy and robotic procedures equally ranged from novice to expert surgeon. At our institution, all patients with endometrial cancer undergo a hysterectomy, bilateral salpingo-oophorectomy, washings, pelvic and para-aortic lymph node dissection according to FIGO staging guidelines. The extent of our aortic lymph node dissection for endometrial cancer staging is to the level of the IMA.

A prospective database of all patients undergoing surgical staging of endometrioid adenocarcinoma of the uterus via laparotomy (LAP), traditional laparoscopy (LSC) and robotics (ROB) at our institution between July 2007 and July 2008 was collected. Approval for this study was obtained by the Northwestern University Institutional Review Board prior to data collection. After diagnosis with clinical early stage endometrioid adenocarcinoma of the uterus, patients were counselled on all three surgical modalities. Counselling included a discussion of relevant data and trends as well as outcomes for each modality and our institutional experience with each surgical approach. Patients provided informed consent, and those electing robotic surgery underwent a discussion of the limited extent of robotics previously performed at the institution. Limitations of patients eligible for minimally invasive surgery included multiple prior abdominal surgeries, evidence of disease outside the uterus, documented history of abdominopelvic adhesions and large uterine size. As our programme has advanced, a past history of documented adhesions and multiple prior abdominal incisions has become less of a limitation for minimally invasive surgery. Body mass index (BMI) was not considered a limiting factor for robotic

approaches. Patients were excluded from a minimally invasive approach and analysis if their diagnosis was papillary serous or clear cell carcinoma of the uterus.

Variables collected and analysed included age, BMI, stage, grade, operative time, estimated blood loss (EBL), length of hospital stay, total lymph node count and complications. Practice management variables were also collected and analysed, including the proportion of staging surgeries performed with minimally invasive surgery and the number of perioperative inpatient days before and after the introduction of robotics. With regards to postoperative analgesia usage, a comparison between all three surgical modalities was performed and narcotic usage was reported in mg of morphine equivalent. Non-narcotic intravenous (i.v.) medication was ketoralac and non-narcotic orally delivered medication was acetaminophen. Conversion from minimally invasive to open procedure was recorded, as well as intraoperative and postoperative complications (major and minor). Major complications included EBL >1500 ml, unplanned admission to the intensive care unit, reoperation, readmission within 15 days of discharge, conversion to laparotomy, transfusion of >4 U packed red blood cells, vascular injury, bowel injury, or injury to the bladder, ureter or urethra. Minor complications included postoperative blood transfusion, postoperative ileus, prolonged intubation, persistent tachycardia, pneumonia, and wound infection not requiring admission. A case was considered converted if the robot was docked to the patient or any laparoscopic instrumentation was introduced into the patient's abdomen prior to converting to laparotomy. Operative time was defined as time from the beginning of skin incision to the completion of skin closure. The operative time for the robotic cases included the docking time, console time and undocking time. Estimated blood loss was determined by the anaesthesiologist and recorded accordingly.

Parametric continuous variables were compared using Student's *t*-test for independent samples. Non-parametric continuous and dichotomous variable comparisons were performed using the Mann–Whitney U-test and the χ^2 test, respectively. Median values are reported unless otherwise noted. $p = 0.05$ was considered statistically significant.

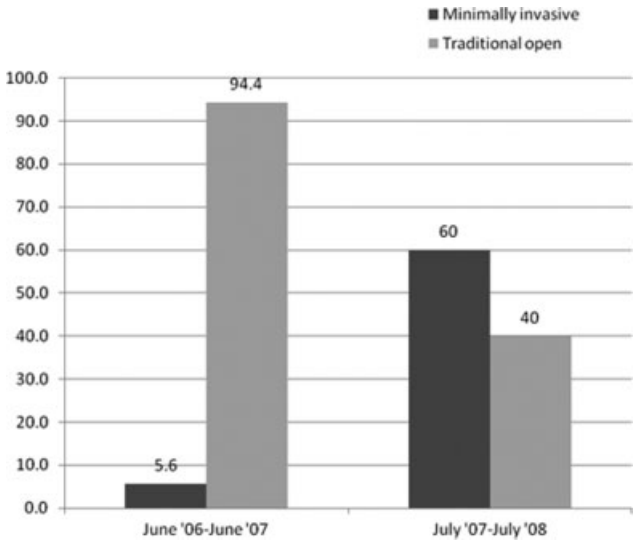

Figure 1. Proportion of early endometrial cancer patients undergoing staging with minimally invasive surgical techniques (laparoscopy or robotics)

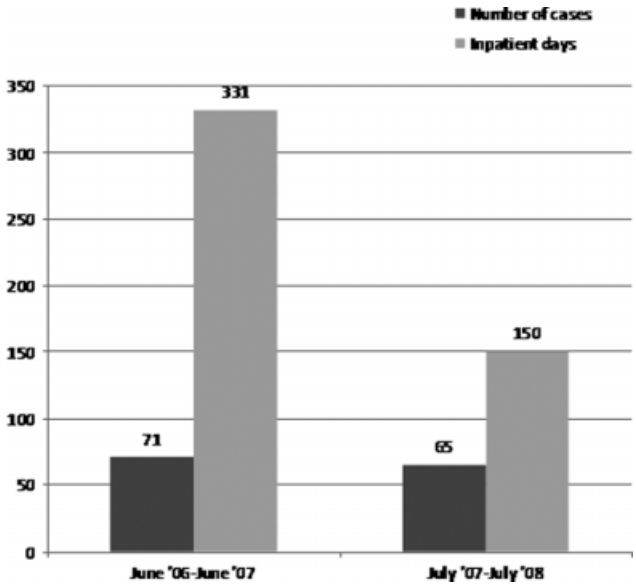

Figure 2. Total number of inpatient days for the perioperative care of endometrial cancer patients before and after the introduction of robotics

Results

Sixty-five patients were identified for this study during the 12 month period. There were 26 patients in the LAP group, seven in the LSC group and 32 in the ROB group. Demographic comparison of the three groups is shown in Table 1. Median age (56 vs. 59 vs. 62; $p = 0.11$) did not differ between the LAP, LSC and ROB groups, respectively. BMI was higher in the LAP group (LAP = 37, range 20–68) than the minimally invasive groups (LSC = 31, range 20–38; ROB = 29, range 21–54; $p = 0.03$). Tumour grade did not significantly differ between groups with grade 1 disease in most patients in each group (ROB 89%, LSC 86%, LAP 58%; $p = 0.29$). Grade 3 disease was seen in 9.4% of the ROB patients and 11.5% of the LAP patients.

Operative outcomes shown in Table 2 show that total lymph node counts (17 vs. 16 vs. 17; $p = 0.92$) did not differ between the LAP, LSC and ROB groups. The ROB and LAP groups had shorter median operating times than the LSC group (195 min for ROB vs. 202 min for LAP vs. 270 min for LSC; $p = 0.023$). The ROB group had lower EBL than both other groups (50 ml for ROB vs. 500 ml for LAP vs. 150 ml for LSC; $p < 0.0001$), a shorter median hospital stay than the LAP group (1 vs. 4 days; $p < 0.0001$) and equal hospital stay to LSC (1 day).

Table 1. Demographics of patients undergoing endometrial staging surgery

	ROB ($n = 32$)	LAP ($n = 26$)	LSC ($n = 7$)	p Value
Age	62	56	59	0.11
BMI	29	37	31	0.03
Grade				0.29
1	88.8	57.7	85.7	
2	21.9	30.8	14.3	
3	9.4	11.5	0	
Stage				0.025
Ia	53.1	26.9	42.9	
Ib	28.1	42.3	42.9	
Ic	3.1	0	0	
IIa	3.1	11.5	0	
IIb	6.3	7.7	0	
IIIa	6.3	0	14.3	
IIIc	0	11.5	0	

Table 2. Perioperative outcomes for patients undergoing surgical staging for early endometrial cancer

	ROB ($n = 32$)	LAP ($n = 26$)	LSC ($n = 7$)	p Value
OR time (min)	195	202	270	0.023
EBL (ml)	50	500	150	<0.0001
Nodal count	17	17	16	0.92
Hospital stay (days)	1	3	1	<0.0001
Conversion to open	1	–	2	–
Complications, major	5	5	2	<0.0001*
Complications, minor	1	14	0	

*Complications significantly different between the open and both robotic and LSC groups, no difference between LSC and robot groups.

Postoperative i.v. analgesia use (median values) was lower in the ROB group compared to both the LSC and LAP group (postoperative day 0, 0 vs. 2.5 vs. 9 mg morphine equivalents, $p < 0.0001$; postoperative day 1, 2.5 vs. 7 vs. 8 mg morphine equivalents, $p = 0.004$). Conversion rate was 29% (2/7) in the LSC group and 3% (1/32) in the ROB group. Major and minor complication rates were significantly lower in the robotic group than in the other two groups (19% ROB vs. 42% LAP vs. 29% LSC; $p = 0.05$).

The LAP group had 19 (five major, 14 minor) complications, in contrast to two in the LSC group (two major, none minor) and six in the ROB group (five major, one minor), as shown in Table 3. Complications in the LSC group were two conversions to laparotomy for extensive adhesions in one patient and high carbon dioxide levels in a second patient with COPD, who was difficult to ventilate. In the LAP group, major complications included one unanticipated transfer to the ICU, one transfusion of >4 U PRBCs, one patient with EBL >1500 ml, one readmission for abdominal wall dehiscence and one reoperation for that dehiscence; the minor complications included one reintubation for laryngospasm, two wound infections, three postoperative blood transfusions, three postoperative ileuses, one prolonged intubation, one acute tubular necrosis and three patients with fluid overload leading to cardiopulmonary work-up or medical diuresis. Major complications in the ROB group included one conversion to open for poor access to the pelvis, one cautery injury to the caecum during lysis of adhesion laparoscopically prior to docking the robot, which was repaired with an endoscopic GIA stapler, and three readmissions for drainage of lymphocysts. These three patients with symptomatic lymphocysts were admitted for IR drainage due to scheduling difficulties, with outpatient management in a timely fashion. The minor complication was copious serous drainage from the right upper quadrant incision in a patient with liver cirrhosis and a history of abdominal ascites that recurred postoperatively, disrupting one of the robotic ports. Final pathology revealed that more patients in the LAP group had stage II disease (19.2% LAP vs. 9.4% ROB vs. 0% LSC; $p = 0.025$).

Practice management outcomes revealed a drastic increase in the proportion of patients managed with a minimally invasive approach after the first year of the robotic surgery programme. The proportion of endometrial cancer patients staged with minimally invasive techniques increased from 5.6% (4/71 cases, all laparoscopically) to 60.0% (39/65 cases, 11% laparoscopically and 49% robotic) in the first year of the programme. The total number of inpatient days for this group of patients decreased from 331 to 150 during the 12 months before and after the robotic surgery programme was established. The total number of cases performed in these early and later time periods was not significantly different (71 vs. 65, respectively)(Figure 1 and 2).

Discussion

The Northwestern University Division of Gynecolog Oncology dramatically changed our practice management of endometrial and cervical cancer within one year. As a result of the commitment of both the institution and the division, rapid change took place for the apparent benefit of patients. The proportion of patients who underwent minimally invasive surgical management of endometrial and cervical cancer increased from 3.3% to 43.5% within 12 months. In the year prior to the robotics programme, all radical hysterectomies and 94.4% of endometrial cancer staging surgeries were done through open techniques. Robotics comprised the largest proportion of the change from open to minimally invasive approaches. This paper details our experience with endometrioid adenocarcinoma of the uterus.

As previously stated, a dedicated robotic surgery programme was introduced into our programme, with goals to expand surgical options for patients, serve as an educational tool for residents and fellows and allow minimally invasive performance of more complex procedures, such as a radical hysterectomy. A manuscript detailing our experience with robotic radical hysterectomy has been submitted for publication. All robotic training of our faculty and fellows occurred within the confines of

Table 3. Complications of patients undergoing surgery for early endometrial cancer

	ROB ($n = 32$)	LSC ($n = 7$)	LAP ($n = 26$)
Minor	Copious drainage from trochar incision		Reintubation
			Wound infections (2)
			Postoperative blood transfusions (3)
			Postoperative ileus (3)
			Prolonged intubation
			Acute tubular necrosis
			Fluid overload requiring work-up (3)
Major	Conversion to open	Conversion to open (2)	Unanticipated ICU stay
	Cautery injury to bowel		Transfusion of >4 U PRBCs
	Readmissions for lymphocysts (3)		EBL >1500 ml
			Readmission
			Reoperation for dehiscence

the division of gynaecological oncology at our institution, and was accomplished in a short period of time. Four of five Gynecologic Oncology faculty were independently performing robotic procedures within 12 months, two dedicated operating room robotics team were developed (two scrub technologists and four nurses) and fully trained within 6 months, and dedicated operating room block time 1 day a week was available to the Division of Gynecologic Oncology for the first 12 months. Currently, the division has dedicated access to a robotic surgical system 2 days/week as our programme has grown, and up to 4 days/week if needed. During the initial 12 months of our robotics programme, the majority of the procedures were performed by a single surgeon within the division (M.P.L.). However, since that time, the proportion of cases has become more equally distributed among the faculty. Our fellows are actively involved in all aspects of robotic surgeries for endometrial cancer (hysterectomy, pelvic and aortic node dissections), including as console operator.

The favourable perioperative outcomes in our series confirm data others have published regarding the feasibility of this surgical modality for staging of early endometrial cancer (1,12,37,38). The drastic decrease in blood loss, comparable operative times and minimal use of narcotic analgesics optimize postoperative recovery from surgery. Short hospital stays and rapid return to work are benefits of both modalities of minimally invasive surgery. Similar lymph node counts in our patients when comparing open and minimally invasive techniques infer that staging was not compromised by the use of these surgical modalities.

The benefit of robotics when compared to traditional laparoscopy is reflected in the high proportion of patients undergoing robotic vs. laparoscopic surgery, the decreased conversion rate of the robotics group (3% vs. 29%), decreased operative time and decreased blood loss. There was a high level of patient interest and acceptability of robotics, even in the early stages of surgeon training in the technique. Although the average BMI was comparable between laparoscopy and robotics, a greater proportion of patients (based on BMI) were eligible for robotics when compared to traditional laparoscopy, for which eligibility is more limited by BMI. Several patients in our series underwent robotic surgery for endometrial cancer who had a BMI in the range 40–54, whereas the largest patient who underwent laparoscopic management had a BMI of 38. Our conversion rate for traditional laparoscopy was comparable to the 23.7% conversion rate found in the randomized phase III LAP-2 trial of the Gynecologic Oncology Group (37). As in the LAP-2 trial, the high conversion rate may be a reflection of the early position on the learning curve for staging via traditional laparoscopy. However, our institution was also early on the learning curve for robotics, with a significantly lower conversion rate. Although the number of cases performed laparoscopically was small, the significantly decreased conversion rate of the robotics group potentially indicates a higher level of ease with complex operations using this technique at our institution. The authors recognize that the small number of patients who underwent a laparoscopic approach is a weakness of our study and can lead to criticism of our data. This small number could be accounted for by an increased interest in robotic techniques recently described in the literature, as well as the known learning curve challenges associated with traditional laparoscopy. However, Boggess *et al*. recently demonstrated similar operative findings comparing three surgical modalities for endometrial cancer, but in a larger patient population (39).

The number of new patients before and after the introduction of robotics did not change in our study. Therefore, we believe this patient cohort did not self-select for minimally invasive surgery, but represents a typical population of endometrial cancer patients at our institution who previously would have been offered only an open surgical technique. Incorporation of a dedicated robotics and minimally invasive programme into our division was pivotal in this change and accelerated the transition from traditional open surgery to minimally invasive approaches. Currently, efforts are being made to further educate our patient population and local referring physicians about robotics and laparoscopy to increase the proportion of patients who are more familiar with their surgical options.

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In conclusion, robotic surgery dramatically altered our surgical approach in the management of endometrioid adenocarcinoma of the endometrium within 12 months. Robotics has become a major component our academic practice, not only for endometrial cancer but also for cervical cancer. At our institution, robotics was associated with a significant improvement in several perioperative outcomes when compared to laparotomy and laparoscopy. Further prospective and multi-institutional trials will be necessary to further compare robotics and laparoscopy to determine superiority.

Conflict of interest

M. Patrick Lowe is a consultant for Intuitive Surgical. There are no other conflicts of interest.

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