Original Article

J Gynecol Oncol Vol. 24, No. 1:21-28
http://dx.doi.org/10.3802/jgo.2013.24.1.21

pISSN 2005-0380
eISSN 2005-0399

Journal of Gynecologic Oncology
jgo

Integration of robotics into two established programs of minimally invasive surgery for endometrial cancer appears to decrease surgical complications

Joel Cardenas-Goicoechea[1], Enrique Soto[2], Linus Chuang[1], Herbert Gretz[1], Thomas C. Randall[3]
Divisions of [1]Gynecologic Oncology and [2]Minimally Invasive Surgery, Department of Obstetrics, Gynecology and Reproductive Science, Mount Sinai School of Medicine, New York, NY; [3]Division of Gynecologic Oncology, Pennsylvania Hospital, University of Pennsylvania School of Medicine, Philadelphia, PA, USA

Objective: To compare peri- and postoperative outcomes and complications of laparoscopic vs. robotic-assisted surgical staging for women with endometrial cancer at two established academic institutions.
Methods: Retrospective chart review of all women that underwent total hysterectomy with pelvic and para-aortic lymphadenectomy by robotic-assisted or laparoscopic approach over a four-year period by three surgeons at two academic institutions. Intraoperative and postoperative complications were measured. Secondary outcomes included operative time, blood loss, transfusion rate, number of lymph nodes retrieved, length of hospital stay and need for re-operation or re-admission.
Results: Four hundred and thirty-two cases were identified: 187 patients with robotic-assisted and 245 with laparoscopic staging. Both groups were statistically comparable in baseline characteristics. The overall rate of intraoperative complications was similar in both groups (1.6% vs. 2.9%, p=0.525) but the rate of urinary tract injuries was statistically higher in the laparoscopic group (2.9% vs. 0%, p=0.020). Patients in the robotic group had shorter hospital stay (1.96 days vs. 2.45 days, p=0.016) but an average 57 minutes longer surgery than the laparoscopic group (218 vs. 161 minutes, p=0.0001). There was less conversion rate (0.5% vs. 4.1%; relative risk, 0.21; 95% confidence interval, 0.03 to 1.34; p=0.027) and estimated blood loss in the robotic than in the laparoscopic group (187 mL vs. 110 mL, p=0.0001). There were no significant differences in blood transfusion rate, number of lymph nodes retrieved, re-operation or re-admission between the two groups.
Conclusion: Robotic-assisted surgery is an acceptable alternative to laparoscopy for staging of endometrial cancer and, in selected patients, it appears to have lower risk of urinary tract injury.

Keywords: Endometrial neoplasms, Laparoscopic surgery, Robotics

Received Apr 17, 2012, **Revised** Jun 8, 2012, **Accepted** Jun 17, 2012

Preliminary data from this manuscript was presented at the Society of Gynecologic Oncology 2011 Winter Meeting (2011 Feb 3–5, Avon, CO, USA).

Correspondence to Thomas C. Randall
Division of Gynecologic Oncology, Pennsylvania Hospital, University of Pennsylvania School of Medicine, 801 Spruce Street, Philadelphia, PA 19107, USA. Tel: +1-215-829-2345, Fax: +1-215-829-2345, E-mail: thomas.randall@uphs.upenn.edu

INTRODUCTION

Endometrial cancer is the most common gynecologic malignancy, with an estimated incidence of 43,470 new cases and 7,950 deaths by 2010 [1] and one of the most common indications for hysterectomy in the field of gynecologic oncology. Advances in the fields of robotics and minimally invasive surgery have allowed the widespread integration of robotic-assisted and laparoscopic procedures into gynecologic oncol-

Copyright © 2013. Asian Society of Gynecologic Oncology, Korean Society of Gynecologic Oncology

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/3.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ogy practices throughout the United States.

The benefits of using a laparoscopic approach to hysterectomy, including a faster return to normal activities, lower blood loss, shorter hospital stay, and fewer wound complications are well documented and has been described in the early 1990s [2]. Additionally, the incorporation of robotics brings unique benefits to surgery including a high resolution three-dimensional (3D) view and intraoperative wrist-like motion of the robotic arms, which provide finer and more dexterous movements. However, the limitations of robotic surgery such as increased cost and operative time [3], as well as the limited experience with this recently developed technology, underline the importance of conducting clinic research in this area of gynecologic oncology.

Currently in the literature, there are few studies to compare robotic-assisted laparoscopic hysterectomy, oophorectomy and lymph node dissection for the staging of endometrial carcinoma to video-laparoscopic approach [4-10]. The authors (JC, TCR) performed a single-site study to compare the peri- and postoperative complications and outcomes of robotic-assisted surgical staging with video-laparoscopic surgical staging for women with endometrial cancer and found that there were no significant differences in the rate of major complications [11]. In order to obtain a more robust dataset that would be widely applicable, we performed a study to analyze the integration of robotics into two established center of minimally invasive surgery for endometrial cancer.

MATERIALS AND METHODS

We conducted a retrospective analysis to identify all the cases of minimally invasive endometrial cancer staging procedures performed by three board certified gynecologic oncologists at two institutions. Patients who underwent additional surgery at the time of the surgical staging or with incomplete data were excluded. All the cases performed by one physician (TCR) were collected from Pennsylvania Hospital between December 2007 and April 2010 for robotic-assisted surgeries and between January 2003 and December 2007 for video-laparoscopic procedures. Similarly, all the robotic-assisted and video-laparoscopic procedures for endometrial cancer were collected for two physicians (HG, LC) from White Plain Medical Center between May 2005 and December 2009. Study was approved by the University of Pennsylvania Health System and Mount Sinai Medical Center Institutional Review Board committee.

A computerized database was created to record age, body mass index (BMI), comorbid medical conditions and surgical approach used for staging (robotic-assisted vs. video-laparoscopic) for each patient. Intraoperative complications recorded included vascular injury, enterotomy, injuries to the urinary tract and conversions to laparotomy; postoperative complications (prior to and after hospital discharge up to 8 weeks of follow-up) were recorded and included vaginal dehiscence, wound complications, urinary tract infections, lymphedema, symptomatic lymphocele, deep vein thrombosis and pulmonary embolism. Perioperative data collected included operative time (defined as Veress needle insertion/skin incision to skin closure), estimated blood loss (EBL), pre- and postoperative hemoglobin values, need for transfusion, length of hospital stay and need for re-operation or re-admission. Pathologic data collected included specimen weight, International Federation of Gynecology and Obstetrics (FIGO) 1988 stage of tumor, histology and grade of tumor and total number of lymph nodes retrieved.

Statistical analysis was performed with SPSS ver. 13.0 (SPSS Inc., Chicago, IL, USA). Continuous data was analyzed with two-sample t-test, and categorical data was conservatively evaluated with Fisher's exact test. Relative risks and 95% confidence interval (CI) were constructed where appropriate, and an alpha was set at 0.05 for statistical significance.

1. Surgical procedure

The surgical techniques for both procedures included pelvic washings, hysterectomy, bilateral salpingo-oophorectomy, and bilateral pelvic and peri-aortic lymphadenectomy at least to the level of the inferior mesenteric artery, with or without postoperative cystoscopy (performed routinely by one of the authors, TCR). Detailed description of the surgical procedure was published before [11] and applied to the cases performed at White Plain Medical center with minor changes.

All patients received prophylactic antibiotics prior to skin incision to reduce the rate of wound infections, and lower extremity sequential compression devices and/or subcutaneous heparin for deep venous thrombosis prophylaxis. A clear diet was offered to patients on the day of surgery and a regular diet on postoperative day one. Pain control was provided with either an intravenous (IV) patient-controlled anesthesia (PCA) narcotic or an oral narcotic with or without a non-steroidal anti-inflammatory drug. A complete blood count was obtained on the first postoperative day. Intravenous fluids were discontinued when the patient tolerated oral fluids. Patients were discharged home when they were able to tolerate a regular diet, ambulate independently, and after adequate pain control was achieved with oral agents.

http://dx.doi.org/10.3802/jgo.2013.24.1.21

RESULTS

1. Study population

Two institutions were part of the study. During the study period, a total of 432 cases fulfilled the inclusion criteria: 187 cases were included in the robotic arm (143 [76%] from Pennsylvania Hospital and 44 [24%] cases from White Plain Medical Center) and 245 cases in the laparoscopic arm (173 [70.6%] from Pennsylvania Hospital and 72 [29.4%] cases from White Plain Medical Center).

At each institution, both arms (robotic vs. laparoscopy) were statistically comparable in terms of baseline characteristics: age, BMI, prior surgery and comorbid condition (p>0.05).

The robotic arm was comparable to the laparoscopic arm in term of demographics when the cases of both institutions were grouped (Table 1). Tumor grade 1 was predominant on both arms and not statistically different between both groups. Even though tumor type was different in both arms, Endometrioid adenocarcinoma was predominant in both arms (Table 2).

2. Surgical staging

Early surgical stage was statistically similar on both arms (stage I: 83.4% vs. 82.1%, respectively; p=0.52). Lymph nodes were histologically documented from pelvis in 96.2% in the robotic arm and 95% in the laparoscopic arm. Para-aortic lymph nodes were histologically documented in 72.7% in the

Table 1. Patient demographics and comorbid conditions for robotic versus laparoscopic hysterectomy and bilateral pelvic and para-aortic lymphadenectomy endometrial cancer

Characteristic	Robotic staging (n=187)	Laparoscopic staging (n=245)	p-value*
Age (yr)			
Mean (SD)	62.1 (9.4)	61.2 (10.5)	0.350†
Median (range)	62 (30–88)	60 (27–80)	
BMI (kg/m^2)		n=244	
Mean (SD)	31.8 (7.95)	31.8 (8.89)	0.980†
Median (range)	31 (17–55)	30 (17–58)	
Prior abdominal surgery (%)	78 (41.7)	110 (44.9)	0.557
Medical history (%)			
Hypertension	103 (55.1)	128 (52.2)	0.561
Coronary artery disease	6 (3.2)	14 (5.7)	0.254
Dyslipidemia	57 (30.5)	72 (29.4)	0.832
Diabetes	31 (16.6)	33 (13.5)	0.412
Obstructive sleep apnea	4 (2.1)	5 (5.0)	1.000
Asthma	8 (4.3)	20 (8.2)	0.117

*p-value from Fisher's exact test. †p-value from two sample t-test.

Table 2. Staging, pathologic findings, and tumor type for robotic versus laparoscopic hysterectomy and bilateral pelvic and para-aortic lymphadenectomy for endometrial cancer

Variable	Robotic staging (n=187)	Laparoscopic staging (n=245)	p-value*
FIGO stage (%)			0.522†
IA	59 (31.6)	81 (33.1)	
IB	69 (36.9)	82 (33.5)	
IC	29 (15.5)	38 (15.5)	
IIA	1 (0.5)	5 (2.0)	
IIB	4 (2.1)	8 (3.3)	
IIIA	10 (5.3)	17 (6.9)	
IIIB	1 (0.5)	0 (0)	
IIIC	13 (7.0)	10 (4.1)	
IVA	1 (0.5)	4 (1.6)	
Grade (%)			0.053†
Grade 1	93 (49.7)	136 (55.6)	
Grade 2	44 (23.5)	67 (27.3)	
Grade 3	50 (26.7)	42 (17.1)	
Tumor type (%)			0.032†
Endometroid	155 (82.9)	219 (89.4)	
Papillary serous	10 (5.3)	12 (4.9)	
MMMT	0 (0)	3 (1.2)	
Clear cell	4 (2.1)	1 (0.4)	
Mixed	10 (5.3)	3 (1.2)	
Carcinosarcoma	8 (4.3)	7 (2.9)	
Lymph nodes‡			
Total lymph nodes	n=183	n=234	
Mean (SD)	18.9 (10.4)	20 (12.1)	0.350
Median (range)	18 (1–53)	18 (1–60)	
95% CI	17.27–20.58	18.50–21.44	
Para-aortic lymph nodes	n=136	n=169	
Mean (SD)	8.92 (5.44)	7.57 (5.79)	0.039
Median (range)	8 (1–27)	6 (1–30)	
95% CI	7.98–9.87	6.69–8.44	
Pelvic lymph nodes	n=180	n=233	
Mean (SD)	12.5 (6.36)	14.6 (8.32)	0.005
Median (range)	12 (1–50)	13 (1–52)	
95% CI	11.4–13.6	13.63–15.57	
Uterine weight (g)	n=166	n=219	
Mean (SD)	131 (98.9)	130 (86)	0.910
Median (range)	100 (29–550)	103 (33–521)	

FIGO, International Federation of Gynecology and Obstetrics; MMMT, malignant mixed Müllerian tumor.
*p-value from two sample t-test. †p-value from Fisher's exact test.
‡Histologically documented.

robotic arm and in 69% in the laparoscopic arm. No difference was noted in the total number of lymph nodes retrieved. More para-aortic lymph nodes were retrieved in the robotic than in the laparoscopic arm (p=0.039), but less pelvic lymph nodes (p=0.005) (Table 2).

The skin to skin operative time was 57 minutes longer in the robotic arm (p=0.0001). Hospital stay was shorter in the robotic arm than in the laparoscopic arm and this difference was maintained after excluding the cases that were converted (1.96 vs. 2.45 days, respectively; p=0.016) (Table 3).

3. Operative outcomes

There was statistically less estimated blood loss in the robotic than in the laparoscopic arm, but not in the rate of blood transfusion (Tables 3, 4). There were 186 (99.5%) patients in the robotic arm and 235 (95.9%) patients in the laparoscopic arm whose surgeries were completed without conversion to laparotomy (conversion rate: 0.5% vs. 4.1%; relative risk [RR], 0.21; 95% CI, 0.03 to 1.34; p=0.0273). One case in the robotic arm required conversion due to poor visualization and 10 cases in the laparoscopic arm due to pulmonary insufficiency, advanced disease, uncontrolled bleeding, uterus size, ureteral injury, hypogastric vein laceration and adhesions (4 cases).

Re-operation rate was similar on both arms (RR, 1.36; 95% CI, 0.83 to 2.22; p=0.44). Indications for re-operation in the robotic arm (7 cases) were: vaginal cuff dehiscence (3 cases), small bowel perforation (postoperative day 1), bowel injury/enterotomy (postoperative day 3), small bowel obstruction (postoperative day 14), and port site hernia repair. Indications for re-operation in the laparoscopic arm (5 cases) were vaginal cuff dehiscence (2 cases), port site hernia repair (2 cases) and bleeding from an area of lymph node dissection on postoperative day 1.

Table 3. Operative time, conversion to laparotomy, blood loss, and hospital stay for robotic vs. laparoscopic hysterectomy and bilateral pelvic and para-aortic lymphadenectomy for endometrial cancer

	Robotic staging (n=187)	Laparoscopic staging (n=244)	p-value*
Operative time (min)			
Mean (SD)	218 (58.8)	161 (58.9)	<0.001
Median (range)	211 (88–437)	152 (69–558)	
Hospital stay (day)			
Mean (SD)	1.96 (2.01)	2.45 (2.08)	0.016
Median (range)	2 (0–19)	2 (1–20)	
Estimated blood loss (mL)	n=183	n=234	
Mean (SD)	110 (82.9)	187 (169)	<0.001
Median (range)	100 (20–500)	150 (20–1,250)	

*p-value from two sample t-test.

4. Intraoperative complications

The rate of urinary tract injury was higher in the laparoscopic arm than in the robotic arm (2.9% vs. 0%, p=0.02). Injuries to the urinary tract consisted of ureteral injuries (5 cases; 1 case was converted to laparotomy for repair), and cystotomies (2 cases; 1 cystotomy was associated to laceration of hypogastric vein and was converted).

There were 4 cases of bowel injury in the robotic arm, one was before docking and was excluded from the analysis (inclusion/exclusion of this case did not alter statistical findings). Two patients had a history of bowel resection as part of treatment of colon cancer; these enterotomies were repaired lapa-

Table 4. Summary of complications for robotic vs. laparoscopic hysterectomy and bilateral pelvic and aortic lymphadenectomy for endometrial cancer

	Robotic staging (n=187)	Laparoscopic staging (n=245)	Risk ratio (95% CI)	p-value*
Intraoperative complication	3 (1.6)	7 (2.9)	-	0.525
Urinary tract	0 (0)	7 (2.9)	-	0.020
Intestinal tract	3 (1.6)	0 (0)	-	0.080
Vascular injury	0 (0)	1 (0.41)	-	1.000
Conversion to laparotomy	1 (0.5)	10 (4.1)	0.21 (0.03–1.34)	0.027
Re-operation	7 (3.7)	5 (2.0)	1.36 (0.83–2.22)	0.440
Blood transfusion	5 (2.7)	5 (2.0)	1.16 (0.62–2.18)	0.751
Intra-hospital complication	23 (12.3)	42 (17.1)	0.79 (0.56–1.12)	0.207
Post-discharge complication	14 (7.5)	19 (7.8)	0.98 (0.65–1.48)	0.937
Re-admission	7 (3.7)	5 (2.0)	1.36 (0.83–2.22)	0.440

Values are presented as number (%).
*p-value from Fischer's exact test.

 http://dx.doi.org/10.3802/jgo.2013.24.1.21

roscopically and the other bowel injury was noted on postoperative day 1.

The overall rate of intraoperative complication was similar in both arms, 3 cases in the robotic arm vs. 7 cases in the laparoscopic arm (1.6% vs. 2.9%, p=0.525) (Table 4).

5. Post-discharge complications

No difference was noted in the rate of complication during the hospital stay (12.3% vs. 17.1%; RR, 0.79; 95% CI, 0.56 to 1.12; p=0.20) nor at the time of the postoperative visit (7.5 % vs. 7.8%; RR, 0.98; 95% CI, 0.65 to 1.48; p=0.93).

The re-admission rate was similar on both arms (3.7% vs. 2.0%; RR, 1.36; 95% CI, 0.83 to 2.22). Reason for re-admission in the robotic arm (7 cases) included a postoperative ileus, vaginal cuff dehiscence (3 cases), pelvic abscess (2 cases) and a pulmonary embolism. Re-admissions in the laparoscopic arm (5 cases) included a port-site hernia, pneumonia, vaginal cuff cellulitis and vaginal cuff dehiscence (2 cases).

There were fewer late minor complications noted in the robotic arm than in the laparoscopic arm but this was not statistically significant (Table 5). Three cases with lymphedema and 4 cases with symptomatic lymphocele were identified in the robotic group; while in the laparoscopic group 1 case with lymphocele was noted.

Table 5. Comparison of late complications for robotic versus laparoscopic approach for endometrial cancer

Complication	Robotic staging (n=187)	Laparoscopic staging (n=245)	p-value*
Major			
Pulmonary embolism	1	0	
Entero-cutaneous fistula	1	0	
Total	2 (1.07%)	0 (0%)	0.186
Minor			
Symptomatic lymphocele	1	4	
Urinary tract infection	2	2	
Pneumonia	0	2	
Wound seroma	0	5	
Vaginal cuff cellulitis	0	2	
Vaginal cuff dehiscence	3	2	
Pelvic abscess	2	0	
Port site hernia	1	2	
Nausea/vomiting	1	0	
Small bowel obstruction	0	1	
Rectus muscle hematoma	0	1	
Port site abscess/infection	0	2	
Lymphedema	0	3[†]	
Total	10 (5.3%)	26 (10.6%)	0.054

*p-value from Fischer's exact test. [†]One case of lymphedema presented with lymphocele at the same time.

DISCUSSION

The safety and feasibility of robotic-assisted surgical staging has been described in multiple studies and is gaining widespread acceptance [12-16]. However, the intraoperative and short term advantages over conventional laparoscopy is less clear, which is important given its relative higher cost [17,18]. The purpose of this study is to overcome two limitations of the prior study: relative small number of cases and single institution experience.

In this cohort study, we have demonstrated that patients undergoing robotic-assisted surgical staging have less urinary tract injuries and blood loss with a shorter hospital stay while having the same overall rate of intraoperative and postoperative complications, and conversion as conventional laparoscopy.

In order to justify the relative higher costs associated with robotic surgery, the known advantages of the da Vinci Surgical System platform need to translate into actual differences in patient clinical outcomes (e.g., intraoperative complications) in comparison to conventional laparoscopy. Unfortunately, the potential advantages can be diluted when the operator has overcome the learning curve of the laparoscopy [19].

In this cohort, patients in the robotic arm have fewer urinary tract injuries than the patients in the laparoscopic arm. This may be explained but multiple factors such as learning curve of laparoscopic approach, complexity of the case, and technical differences inherent to the robotic platform. Up to this publication, there is no a single publication that reported a case of urinary tract injury [4-9] (Table 6). The clinical impact of this difference is relevant because 28% (2 cases) were converted to laparotomy.

Our overall rate of intraoperative complications was not statistically different between the 2 arms (1.6% vs. 2.9%; p=0.525). Boggess et al. [9] reported an incidence of 1% in the robotic group (bowel injury) and 3.7% in the laparoscopic group (cystostomy, bowel injury, caval injury). Lim et al. [4] had no intraoperative complication in the robotic group but 12.5% in the laparoscopic group (3 obturator nerve palsy, 2 cystotomy repair, 1 enterotomy repair, venotomy). In the current study, no significant difference was found between the 2 arms in the intra-hospital and post-discharge complication rate. This has been a stable finding across published studies (Table 6).

The statistically reduced estimated blood loss in the robotic

Table 6. Summary of reports on outcomes on robotic-assisted versus laparoscopic (LSC) surgical staging for endometrial cancer

Author, year	Arm (n)	Conversion (%)	Complication (%)			Blood transfusion (%)	Urinary tract injury (n)	Bowel injury (n)	Hospital stay (mean, day)	Lymph nodes			Operative time (min)	Estimated blood loss (mL)
			Overall	Major	Minor					Pelvic	Para-aortic	Total		
Lim, 2010 [4]†	Robotic (56)	1.7	14.3	5.4	8.9	-	0	0	1.6*	19.2*	12.9*	26.7*	162*	89*
	LSC (56)	7.1	21.4	17.9	3.6	-	2	1	2.6	24.1	20.9	45.1	192	209
Jung, 2010 [5]†	Robotic (28)	0	7.1	-	-	14.3	0	0	7.92	21.14*	7.71*	-	193.18*	-
	LSC (25)	0	8	-	-	16	0	0	7.62	18.36	4.41	-	165.2	-
Seamon, 2009 [6]	Robotic (105)	12.4*	13	-	-	3*	0	3	1*	21	10	-	242*	88*
	LSC (76)	26.3	14	-	-	18	1	0	2	22	11	-	287	200
Hoekstra, 2009 [7]†	Robotic (32)	3	18.7	15.6	3.1	-	0	1‡	1	-	-	17	195*	50*
	LSC (7)	29	18.6	28.6	0	-	0	0	1	-	-	16	270	150
Bell, 2008 [8]†	Robotic (40)	-	7.5*	-	-	5	0	0	2.3	-	-	17	184	166
	LSC (30)	-	20	-	-	10	0	0	2	-	-	17.1	171	253
Boggess, 2008 [9]†	Robotic (103)	2.9	5.8	-	-	1	0	1	1.0*	20.5	12.0*	32.9*	191.2*	74.5*
	LSC (81)	4.9	13.6	-	-	2.5	1	1	1.2	17.4	6.3	23.1	213	145.8
Veljovich, 2008 [10]†	Robotic (25)	-	-	-	-	-	-	-	1.6	-	-	17.5	283	66.6
	LSC (4)	-	-	-	-	-	-	-	1.2	-	-	20.3	255	75
Present study	Robotic (187)	0.5	-	1.07	0.53	2.7	0*	3	1.96*	12.5*	8.92*	18.9	218*	110*
	LSC (245)	4.1	-	0	9.8	2	7	0	2.45	14.6	7.52	20	161	187
Total	Robotic (551)	-	-	-	-	-	0*	7	-	-	-	-	-	-
	LSC (520)	-	-	-	-	-	11	2	-	-	-	-	-	-

*$p<0.05$. †Study compared robotic, LSC and open approaches. ‡Cautery injury to the cecum prior docking.

http://dx.doi.org/10.3802/jgo.2013.24.1.21

arm is the most consistent finding with other publications (Table 6). In a meta-analysis that included 397 patients, the use of the robot was associated with a significantly reduced blood loss during surgery: mean difference, 75.96 mL (95% CI, -142.39 to -9.53) [20]. Importantly, the finding of decreased blood loss may not be clinically significant since it did not translate into a reduced rate of blood transfusions. This observation is consistent with other studies in the literature (Table 6).

The reported hospital stay has been consistent across published studies in America and ranges from 1 to 1.6 days (robotic) vs. 1 to 2.6 days (laparoscopic) (Table 6). In the current study this difference was statistically significant with no difference in the rate of re-admission (3.7% in the robotic arm vs. 2.0% in the laparoscopic arm; RR, 1.36; 95% CI, 0.83 to 2.2; p=0.44). This finding is consistent with a meta-analysis that included 431 patients, where the hospital stay was shorter in the robotic approach than in the laparoscopic for surgical staging for endometrial cancer: mean difference, -0.17 days (95% CI, -0.28 to -0.06) [20]. However, Gaia et al. [21] reported no difference in a systematic review that included 589 robotic and 396 laparoscopic cases. This may reflect the heterogeneity of care represented when a study includes data from multiple, disparate centers.

Though our conversion rate was low in both arms, the robotic arm was favored but did not reach statistical significance (0.5% vs. 4.1%; RR, 0.21; 95% CI, 0.03 to 1.34; p=0.02) and may not reflect widespread conversion rates for laparoscopies performed for this indication (Table 6). The GOG LAP2 trial for example, found a 25.8% overall conversion rate in the laparoscopic arm for surgical staging for endometrial cancer; this high conversion rate was associated with increasing age, BMI, and metastatic disease and represents the only randomized controlled trial to date [22].

In centers dedicated to minimally invasive surgery where the surgeon has overcome some of the limitations of the video-laparoscopic platform, the robotic platform may not represent an advantage. Our clinical experience and our reading of the literature suggest however, that the use of the robotic platform can shorten the learning curve [4,23,24] and our skin to skin operative time did not favor the robotic arm which was 57 minutes longer for the robotic arm. Gaia et al. [21] found a longer operative time for the robotic approach. Previous publications show conflicted data which reflects variation in the definition, type of study (prospective vs. retrospective), surgeon experience, surgical team, hospital setting (academic vs. non-academic center), proficiency of assistant (e.g., fellow), and/or volume of cases. Given the technical advantages of the robotic platform, a shorter operative time in the robotic arm would be expected. Our experience suggests that operative time continues to decrease as individual surgeons and centers increase their experience (especially beyond 500 to 1,000 cases).

Our total lymph node retrieved was similar in the robotic and laparoscopic arm. Other studies, reported higher lymph node retrieved in favor of the robotic arm, presumably due to the wrist-like motion of the robotic arms and/or the 3D visualization which may help overcome the anatomic barriers (Table 6). However, Reza et al. [20] found no difference in the lymph node retrieved in a meta-analysis when compared robotic versus laparoscopy for surgical staging.

The current study represents the largest series to date to compare robotic-assisted to traditional laparoscopy for the staging of endometrial carcinoma. While some of the weaknesses of prior studies (e.g., single institution) were targeted in the study design, we acknowledge that the inherent limitations of retrospective studies, such as lack of randomization, are present. Quality of life, return to work, and the impact on overall survival are important outcomes that deserve further study.

Robotic-assisted surgery is an acceptable alternative to laparoscopy for staging of endometrial cancer. Our experience suggests that the use of robotics in this setting may reduce the risk of urinary tract injury.

CONFLICT OF INTEREST

Linus Chuang, MD is a consultant for Intuitive Surgical and Herbert Gretz, MD is a proctor for Intuitive Surgical and consultant for Ethicon.

ACKNOWLEDGMENTS

The authors are grateful to German V. Valenzuela, MD for his assistance with the statistical analysis.

REFERENCES

1. Jemal A, Siegel R, Xu J, Ward E. Cancer statistics, 2010. CA Cancer J Clin 2010;60:277-300.
2. Childers JM, Brzechffa PR, Hatch KD, Surwit EA. Laparoscopically assisted surgical staging (LASS) of endometrial cancer. Gynecol Oncol 1993;51:33-8.
3. Pasic RP, Rizzo JA, Fang H, Ross S, Moore M, Gunnarsson C. Comparing robot-assisted with conventional laparoscopic hysterectomy: impact on cost and clinical outcomes. J

Minim Invasive Gynecol 2010;17:730-8.
4. Lim PC, Kang E, Park DH. Learning curve and surgical outcome for robotic-assisted hysterectomy with lymphadenectomy: case-matched controlled comparison with laparoscopy and laparotomy for treatment of endometrial cancer. J Minim Invasive Gynecol 2010;17:739-48.
5. Jung YW, Lee DW, Kim SW, Nam EJ, Kim JH, Kim JW, et al. Robot-assisted staging using three robotic arms for endometrial cancer: comparison to laparoscopy and laparotomy at a single institution. J Surg Oncol 2010;101:116-21.
6. Seamon LG, Cohn DE, Henretta MS, Kim KH, Carlson MJ, Phillips GS, et al. Minimally invasive comprehensive surgical staging for endometrial cancer: robotics or laparoscopy? Gynecol Oncol 2009;113:36-41.
7. Hoekstra AV, Jairam-Thodla A, Rademaker A, Singh DK, Buttin BM, Lurain JR, et al. The impact of robotics on practice management of endometrial cancer: transitioning from traditional surgery. Int J Med Robot 2009;5:392-7.
8. Bell MC, Torgerson J, Seshadri-Kreaden U, Suttle AW, Hunt S. Comparison of outcomes and cost for endometrial cancer staging via traditional laparotomy, standard laparoscopy and robotic techniques. Gynecol Oncol 2008; 111:407-11.
9. Boggess JF, Gehrig PA, Cantrell L, Shafer A, Ridgway M, Skinner EN, et al. A comparative study of 3 surgical methods for hysterectomy with staging for endometrial cancer: robotic assistance, laparoscopy, laparotomy. Am J Obstet Gynecol 2008;199:360.e1-9.
10. Veljovich DS, Paley PJ, Drescher CW, Everett EN, Shah C, Peters WA 3rd. Robotic surgery in gynecologic oncology: program initiation and outcomes after the first year with comparison with laparotomy for endometrial cancer staging. Am J Obstet Gynecol 2008;198:679.e1-9.
11. Cardenas-Goicoechea J, Adams S, Bhat SB, Randall TC. Surgical outcomes of robotic-assisted surgical staging for endometrial cancer are equivalent to traditional laparoscopic staging at a minimally invasive surgical center. Gynecol Oncol 2010;117:224-8.
12. Vaknin Z, Perri T, Lau S, Deland C, Drummond N, Rosberger Z, et al. Outcome and quality of life in a prospective cohort of the first 100 robotic surgeries for endometrial cancer, with focus on elderly patients. Int J Gynecol Cancer 2010; 20:1367-73.
13. Lee CL, Han CM, Su H, Wu KY, Wang CJ, Yen CF. Robot-assisted laparoscopic staging surgery for endometrial cancer: a preliminary report. Taiwan J Obstet Gynecol 2010;49:401-6.
14. Gocmen A, Sanlikan F, Ucar MG. Comparison of robotic-assisted surgery outcomes with laparotomy for endometrial cancer staging in Turkey. Arch Gynecol Obstet 2010;282:539-45.
15. duPont NC, Guru KA, Iskander GB, Odunsi K, Lele SB, Rodabaugh KJ. Instituting a robot-assisted surgery programme at a tertiary care cancer centre. Int J Med Robot 2010;6:330-3.
16. duPont NC, Chandrasekhar R, Wilding G, Guru KA. Current trends in robot assisted surgery: a survey of gynecologic oncologists. Int J Med Robot 2010;6:468-72.
17. Holtz DO, Miroshnichenko G, Finnegan MO, Chernick M, Dunton CJ. Endometrial cancer surgery costs: robot vs laparoscopy. J Minim Invasive Gynecol 2010;17:500-3.
18. Barnett JC, Judd JP, Wu JM, Scales CD Jr, Myers ER, Havrilesky LJ. Cost comparison among robotic, laparoscopic, and open hysterectomy for endometrial cancer. Obstet Gynecol 2010;116:685-93.
19. Seamon LG, Fowler JM, Richardson DL, Carlson MJ, Valmadre S, Phillips GS, et al. A detailed analysis of the learning curve: robotic hysterectomy and pelvic-aortic lymphadenectomy for endometrial cancer. Gynecol Oncol 2009;114:162-7.
20. Reza M, Maeso S, Blasco JA, Andradas E. Meta-analysis of observational studies on the safety and effectiveness of robotic gynaecological surgery. Br J Surg 2010;97:1772-83.
21. Gaia G, Holloway RW, Santoro L, Ahmad S, Di Silverio E, Spinillo A. Robotic-assisted hysterectomy for endometrial cancer compared with traditional laparoscopic and laparotomy approaches: a systematic review. Obstet Gynecol 2010;116:1422-31.
22. Walker JL, Piedmonte MR, Spirtos NM, Eisenkop SM, Schlaerth JB, Mannel RS, et al. Laparoscopy compared with laparotomy for comprehensive surgical staging of uterine cancer: Gynecologic Oncology Group Study LAP2. J Clin Oncol 2009;27:5331-6.
23. Seamon LG, Cohn DE, Richardson DL, Valmadre S, Carlson MJ, Phillips GS, et al. Robotic hysterectomy and pelvic-aortic lymphadenectomy for endometrial cancer. Obstet Gynecol 2008;112:1207-13.
24. Lowe MP, Johnson PR, Kamelle SA, Kumar S, Chamberlain DH, Tillmanns TD. A multiinstitutional experience with robotic-assisted hysterectomy with staging for endometrial cancer. Obstet Gynecol 2009;114:236-43.

http://dx.doi.org/10.3802/jgo.2013.24.1.21