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TECHNIQUES AND INSTRUMENTATION

A hybrid technique of combined conventional and robotic-assisted laparoscopy for staging and debulking of early, advanced, and recurrent ovarian, fallopian tube, and primary peritoneal cancer

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Abstract This study aims to describe a hybrid laparoscopic and robotic-assisted laparoscopic technique to access all four abdominal quadrants during pelvic procedures. This technique was utilized in the surgical management of select cases that included early, advanced, and recurrent ovarian, fallopian tube, and peritoneal cancer. A retrospective analysis of a prospectively maintained database was used to extract cases that this surgical method was utilized in. This included 20 patients that underwent 21 surgical procedures using this hybrid technique of conventional laparoscopy and robotic-assisted laparoscopy. Ten were early stage, and 11 were advanced and/or recurrent (six advanced, five recurrent). In the early-stage group, mean age was 42.3 years (range, 29–55), average BMI was 32.1 kg/m^2 (range, 17–65 kg/m^2), mean blood loss was 212.5 ml (range, 50–1,000 mL), operating room time (ORT) was 306.1 min (range, 87–639), and average length of stay (LOS) was 1.6 days (range, 1–2). There were no intraoperative complications and two grade 1 postoperative complications. Of the 11 for advanced and/or recurrent disease, mean age was 63.9 years (range, 39–92), average BMI was 29.7 kg/m^2 (range, 22.1–37.2), mean blood loss was 129.1 ml (range, 20–400), ORT was 238 min (range, 103–477), and LOS was 3.8 days (range, 1–17). There were no intraoperative complications. Three cases had postoperative grade 1–3 complications. There was one second look, nine cytoreductions to no visible disease, and 1 to <0.5 cm. Use of this hybrid technique, combining conventional laparoscopy and the present robotic platform, is effective in the surgical management of early, advanced and recurrent ovarian, fallopian tube, and peritoneal cancer in accessing all four abdominal quadrants with pelvic surgery.

Keywords Hybrid technique · Conventional laparoscopy · Robotic-assisted laparoscopy · Ovarian cancer Staging and Cytoreduction

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Introduction

Advances in minimally invasive surgical techniques now make it feasible to accomplish comprehensive surgical staging, using conventional or robotic-assisted laparoscopy in select patients [1]. The present computer enhanced telesurgery (Intuitive Surgical, Sunnyvale, CA, USA), called robot-assisted surgery, was approved by the Food and Drug Administration for gynecological surgery in 2005 and has been increasingly applied to complex gynecologic procedures, such as surgical staging for gynecologic malignancies including endometrial, cervical, and ovarian cancers [2–5].

Limitations exist with the present robotic platform for staging and cytoreduction in ovarian cancer. Once the robot is docked for pelvic surgery, it is more difficult to access the upper abdomen, without having to undock and reposition the robot, or add additional ports to be able to perform the procedure. The Society of Gynecologic Oncology's consensus statement on robotic-assisted surgery commented on its utility in ovarian cancer as poorly suited for advanced ovarian cancer due to its limitation, with conventional port placement for pelvic surgery, in gaining upper abdominal access [6].

In the USA, ovarian cancer will affect approximately 22,280 women in 2012 with 15,500 estimated deaths. Currently, the lifetime risk of developing ovarian cancer in the USA is approximately 1 in 70 with more than 65 % given the diagnosis of advanced stage disease [7]. The standard treatment of ovarian cancer includes upfront surgery with intent to properly diagnose, stage, and to achieve maximal cytoreduction preferably to no visible disease followed by taxanes and platinum-based combination chemotherapy in majority of cases [8]. Traditionally, a comprehensive surgical staging procedure for ovarian, fallopian tube, and primary peritoneal cancers include total abdominal hysterectomy, bilateral salpingo-oophorectomy, peritoneal washings, biopsies of adhesions and peritoneal surfaces, omentectomy, and retroperitoneal lymph node sampling from the pelvic and para-aortic regions through a generous vertical midline laparotomy incision.

There have been attempts to strategize the utility of the robot for such cases in order to gain upper abdominal access without difficulty. Magrina et al. described their technique for approaching debulking procedures in patients with epithelial ovarian cancer that require upper abdominal access and for infrarenal aortic lymphadenectomy. This method involves undocking the robotic arms, then rotating the operating table 180°, insertion of additional ports, and then redocking [5, 9].

We describe our surgical method, a hybrid technique, in which both conventional laparoscopy and the robot are utilized in gynecologic malignancies in all four abdominal quadrants and the pelvic cavity. This surgical technique and its use in select patients with early and advanced ovarian cancer will be described for laparoscopic management of both pelvic and upper abdominal disease.

Materials and methods

A retrospective analysis of a prospectively maintained database was performed to extract select cases where this hybrid technique combining conventional laparoscopy (CL) and robotic-assisted laparoscopic surgery (RALS) was utilized. These cases included early, advanced, and recurrent ovarian, fallopian tube, and peritoneal cancer. Institutional review board approval was obtained and data was collected from two urban university affiliated community hospitals. All patients underwent preoperative evaluation including history, physical examination, medical assessment, computed tomography imaging of the chest or abdomen and pelvis, or positron emission tomography scan, and tumor marker assays, and were counseled extensively preoperatively and appropriate informed consent was obtained. Patients with significant perioperative morbidity who were not candidates for any surgical procedures, either laparoscopy or laparotomy, or who had significant metastatic disease involving chest or solid organs, such as liver, were excluded. The same board-certified gynecologist oncologist, assisted by a minimally invasive gynecological surgical fellow and resident performed the surgeries. Early stage disease included patients that were in stages I to II. This group also included patients referred for restaging after prior ovarian cystectomy or oophorectomy. Advanced disease was classified as International Federation of Gynecology and Obstetrics stages III to IV. Postoperative complications were graded using the Memorial Sloan-Kettering Cancer Center severity grading system [10].

Technique

Under general endotracheal anesthesia, the patients were positioned in dorsal lithotomy position, bilateral sequential compression devices were placed on both lower extremities and arms were padded and tucked. Egg crate foam was also placed across the chest to protect patients and they were secured to the operating table with tape or a gel pad underneath them. They were draped in a sterile manner, and given preoperative antibiotic prophylaxis with 1–2 g of cefazolin or 80 mg or gentamycin and 900 mg of clindamycin if they were allergic to penicillin. A Foley catheter was inserted into the bladder, and a uterine manipulator was placed if the uterus was in situ. An incision is made in either the left upper quadrant or 4–5 cm above the umbilicus, using a Veress needle to introduce carbon dioxide gas and establish pneumoperitoneum. After adequate pneumoperitoneum is obtained, a 5 or 8 mm primary port is inserted into the left upper quadrant. If pneumoperitoneum is established supraumbilically, then a 12-mm trocar and sleeve are introduced into the supraumbilical port. After assessing the abdominopelvic cavity, either a 10- or 12-mm port is introduced into the right upper quadrant or two 8-mm robotic ports are introduced 8–10 cm lateral to the umbilicus bilaterally (Fig. 1). Further peritoneal inspection is performed by conventional laparoscopy and peritoneal washings or aspiration of existing ascites are obtained and sent for cytology. Decision to proceed with laparoscopic/robotic-assisted surgical or laparotomy staging or debulking was made based on the extent of the disease and patients comorbidity for lengthy operation. In advanced stages, the goal was to achieve cytoreduction to preferably no visible or at least <1 cm disease either via robotic-assisted laparoscopy, conventional laparoscopy, or laparotomy.

Fig. 1 Port placement

Thorough four-quadrant abdominopelvic cavity evaluation was performed by inserting additional ports, when necessary, to implement the choice of treatment. If surgical debulking to no visible disease is not possible, then biopsies are taken and salpingo-oophorectomy is performed if feasible [11, 12]. The procedure is terminated and the patient is given neoadjuvant chemotherapy to achieve higher rate of optimal cytoreductive surgery and decrease morbidity [13]. The patient is then reoperated on after reducing the load of the disease, which has been shown in randomized trials not to compromise oncological outcomes. Only patients in whom this hybrid technique was utilized were included in this study.

If disease is present in the upper abdomen and pelvis, surgery begins with conventional laparoscopy to perform an omentectomy and upper abdominal debulking (Fig. 2). This is performed via use of the supraumbilical port for the camera and ports for introduction of instruments. The surgeon stands between the patient's legs with two assistants on either side of the patient and an additional monitor placed towards the patient's head. A combination of various conventional laparoscopic instruments such as the Harmonic shears, the 5- or 10-mm LigaSure™ (Covidien, Boulder, CO) or other blood vessel sealant devices including surgical clips and staples can be used. The infracolic omentum is transected from the transverse colon and the gastrocolic omentum is transected all the way towards the spleen and stomach by coagulating and transecting the short gastric vessels. The specimen(s) is removed confined to a laparoscopic bag. Metastatic lesions noted on the hepatic flexure or transverse colon are mobilized. Using a combination of Harmonic shears (Ethicon Endo-Surgery, Cincinnati, OH, USA), PlasmaJet (Plasma Surgical Limited, Oxfordshire, UK), and bipolar electrocoagulation, all diaphragmatic lesions are removed in the form of stripping, ablation, and coagulation (Fig. 2a,b). This same approach can be applied if there is no upper abdominal disease and only infracolic omentectomy is performed as part of surgical staging for presumed early ovarian cancer.

Any abdominal and pelvic adhesions which interfere with proper application of the robotic platform are lysed using conventional laparoscopy. After the upper abdominal portion is performed, the robotic apparatus is side docked on the patient's left side, using the supraumbilical port for the camera and the bilateral robotic 8-mm ports. The posterior parietal peritoneum over the right common iliac is incised and retroperitoneal dissection is completed cephalad to above inferior mesenteric artery. We use the electrosurgical spatula or scissors as a cutting modality and bipolar forceps for achieving hemostasis. The left and right upper assist ports are utilized for introduction of ancillary instruments for traction, tissue removal, as well as suction and irrigation. After para-aortic lymphadenectomy is completed, pelvic lymphadenectomy, hysterectomy, bilateral salpingo-oophorectomy, and any pelvic tumor debulking are performed (Fig. 3). The same

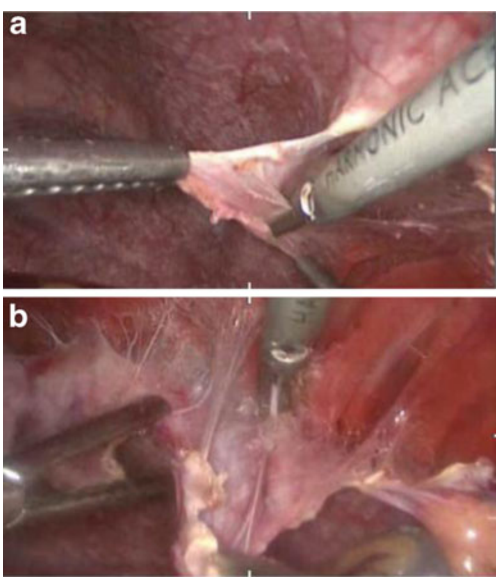

Fig. 2 **a** Diaphragmatic stripping of peritoneum with grasper and Harmonic scalpel (Ethicon Endosurgery, Cincinnati, OH, USA). **b** Diaphragmatic stripping showing stripped-away peritoneum and the underlying muscle fibers

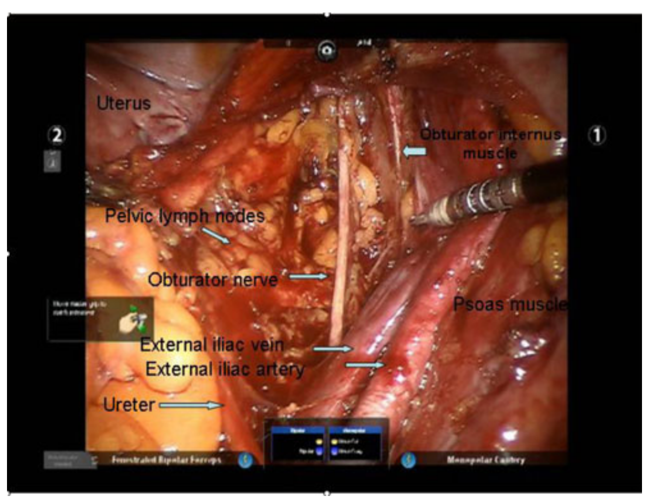

Fig. 3 Right pelvic sidewall exposing the iliac vessels and obturator fossa for robotic-assisted laparoscopic pelvic lymphadenectomy

instrumentation utilized is as before, or at times, standard blood vessel sealing devices such as the LigaSure(Covidien, Boulder, CO, USA), etc. can be employed for ligation of the infundibular ligaments and performing hysterectomy. If access to the para-aortic lymph nodes above the inferior–mesenteric artery is not possible using the robotic platform setup, this portion of the operation is performed using a conventional laparoscopic approach after undocking the robot or the camera is moved from supraumbilical port to the right upper quadrant one. After the uterus is transected, it is removed from the vagina along with the omentum and any other specimens, which are confined to a laparoscopic specimen bag. The vaginal cuff is closed in two layers. After complete hemostasis is achieved, the robotic apparatus is undocked.

Bowel resections can be performed with conventional laparoscopy and robotically using the appropriate port and robot placement. In case of the need for mid-abdominal debulking, such as appendectomy or ileocecal resection, mobilization of the bowel is performed using the robotic platform, and appendectomy or bowel resection is performed using a stapling device introduced in the right upper abdominal port. Anastomosis can be performed either in situ or extracorporeally by extending the supraumbilical incision after pelvic tumor debulking and undocking the robot. This approach can be utilized for segmental transverse colon resection and reanastomosis to achieve optimal cytoreduction to no visible disease. For rectosigmoid colon resection and anastomosis, we use a 12-mm port in the right lower abdomen for introduction of the stapling device. This is especially true for a bulky lesion involving the rectosigmoid colon. Using a laparoscopic 60 mm GIA stapler, a rectosigmoid resection can be performed proximally and distally. Once the proximal sigmoid colon is appropriately mobilized, this end can be brought out through a widened incision in the right lower quadrant, lower middle incision, or transvaginally along with the specimen. An anvil can then be placed and secured with a purse string suture. The anvil and proximal sigmoid colon is then brought back into the pelvis and an end-to-end anastomosis can be performed with an end-to-end anastomosis stapler passed through the rectum. Once the device is properly activated, it is important to test the integrity of the anastomosis. This can be accomplished by clamping the proximal colon with a bowel grasper, filling the pelvis with saline, and insufflating the rectum with air while observing laparoscopically. The anastomosis can be alternatively or additionally examined by filling the rectum with indigo carmine and observing for leakage. Cystoscopy is routinely performed to ensure that there is no damage to the bladder or ureters. Ports are removed and port sites are closed in a routine manner.

In the case of recurrences that occur primarily in the upper abdomen, debulking can be performed with the robotic apparatus. In this situation, after exploratory laparoscopy and peritoneal washings are performed using conventional laparoscopy, the robot is side docked from above the patient on the right side using the same port placement as above (Fig. 1) and instrumentation is as described previously.

Results

There were 20 women that underwent 21 surgical procedures for the management of early, advanced, and recurrent ovarian, fallopian tube, or peritoneal cancer using our hybrid technique of conventional laparoscopy and RALS. There were 10 surgical procedures performed for early stage disease and 11 for advanced and/or recurrent disease (six advanced and five recurrent). The early group consisted of three cases that were stage IA (Table 1; cases 1–3), six that were stage IC (Table 1; cases 4–9), and one case that was stage IIC (Table 1, case 10). The advanced and recurrent group consisted of seven cases that were advanced, with six cases that were stage IIIC (Table 2: cases 1,2,3,5,7 and 11), one case that was stage IV (Table 2: case 4). The remainder in this group had recurrent disease (Table 2: cases 6,8,9, 10). There were no conversions to laparotomy in either group.

Of the 10 surgeries for early stage disease, the mean age was 42.3 years (range, 29–55), average BMI was 32.1 kg/m^2 (range, 17–65 kg/m^2), average estimated blood loss (EBL) was 212.5 ml (range, 50–1,000 mL), surgical time was 306.1 min (range, 87–639), and average length of stay (LOS) was 1.6 days (range, 1–2). In this group, the surgical procedures performed included five hysterectomies, eight oophorectomies, one cystectomy, eight omentectomies, five pelvic lymph node dissections (average, 10.3; range, 5–18), four para-aortic lymph node dissections (average, 8.6; range, 3–12), four appendectomies, and seven upper abdominal and diaphragmatic biopsies. None of these patients were upstaged after surgical and pathological staging.

There were no intraoperative complications or intraoperative transfusions, and two grade 1 postoperative complications. One patient was readmitted on postoperative day 9 with a wound infection. The other was readmitted with fever of unknown origin that resolved with IV antibiotics.

Three patients in this group underwent fertility sparing surgery (Table 1; cases 6, 8, and 9) [14]. In the first case listed (Table 1), the para-aortic lymphadenectomy was performed laparoscopically as there was difficulty with adequate visualization when the robotic apparatus was docked. Four patients in the early ovarian cancer group had prior surgical intervention and presented for restaging (Table 1; cases 3, 5, 8, and 9). Two patients in this group did not have an omentectomy (Table 1; cases 2 and 6). Case 2 was a double primary that was initially staged for endometrial cancer with final pathology that showed ovarian cancer as a second primary. Case 6 presented for restaging, after prior left salpingo-oophorectomy and staging.

Table 1 Early stage ovarian cancer cases

Case	Age	BMI	Procedure: Laparoscopic	Procedure: Robotic	Pathology	EBL	ORT	LOS	Complications
1	52	17	Infracolic omentectomy, para-aortic lymphadenectomy, diaphragmatic biopsy, right upper abdominal peritoneal biopsy, peritoneal washings	LAVH, left oophorectomy, pelvic lymphadenectomy, appendectomy, peritoneal biopsies	Grade 3 serous carcinoma of the fallopian tube	200	n/a	2	None
2	53	21	Exploratory laparoscopy, peritoneal washings	Pelvic and para-aortic lymphadenectomy, hysterectomy, BSO	Grade 3 endometrioid adenocarcinoma of the ovary	150	366	2	None
3	54	40	Infracolic omentectomy, peritoneal biopsies, diaphragmatic biopsy and upper abdominal peritoneal biopsies, peritoneal washings	Lysis of extensive small bowel and pelvic adhesions, bilateral pelvic lymphadenectomy, peritoneal biopsies, total hysterectomy	Grade 3 serous carcinoma of the ovary	150	361	2	Admission on POD#21 for FUO
4	38	25	Infracolic omentectomy, appendectomy, upper abdominal peritoneal biopsies, peritoneal washings	Para-aortic lymphadenectomy, pelvic lymphadenectomy, hysterectomy, LSO, peritoneal biopsies	Mucinous low malignant potential tumor of the ovary	100	338	2	Wound infection
5	55	27	Upper abdominal peritoneal biopsies, peritoneal washings	Infracolic omentectomy, hysterectomy, LSO	Serous low malignant potential tumor of the ovary	50	178	1	None
6	34	23	Upper abdominal biopsies, peritoneal washings	Pelvic and para-aortic lymphadenectomy, RSO, peritoneal biopsies, lysis of pelvic adhesions	Grade 3 mucinous adenocarcinoma of the ovary	125	271	1	None
7	30	53	Infracolic omentectomy, peritoneal washings	Right ovarian cystectomy, resection of pelvic endometriosis, appendectomy, myomectomy, peritoneal biopsies	Serous low malignant potential tumor of the ovary	50	87	1	None
8	29	22	Infracolic omentectomy, resection of diaphragmatic lesions, peritoneal biopsies, peritoneal washings	Resection of pelvic lesions, LSO, peritoneal biopsies, LOA	Grade 2 immature ovarian teratoma	200	172	1	None
9	31	28	Infracolic omentectomy, diaphragmatic biopsies, upper abdominal peritoneal biopsies, peritoneal washings	LSO, resection of pelvic lesions and endometriosis, pelvic and para-aortic lymphadenectomy, peritoneal biopsies, LOA	Grade 2 endometrioid adenocarcinoma of the ovary	100	343	1	None
10	47	65	Infracolic omentectomy	Radical hysterectomy, BSO, tumor debulking, resection of endometriosis, appendectomy, peritoneal biopsies, , extensive LOA	Grade 1 endometrioid adenocarcinoma of the ovary	1000	639	3	None

BMI body mass index, *EBL* estimated blood loss, *ORT* operating room time, *LOS* length of stay, *LAVH* laparoscopic-assisted vaginal hysterectomy, *BSO* bilateral salpingo-oophorectomy, *LSO* left salpingo-oophorectomy, *D&C* dilation and curettage, *POD* postoperative day, *LOA* lysis of adhesions

Table 2 Advanced and recurrent ovarian cancer cases

Case	Age	BMI	Disease status	Procedure: Laparoscopic	Procedure: Robotic	Procedure: Other	Pathology	Status of cytoreduction	EBL	ORT	LOS	Complications
1	92	24.7	Advanced	Total omentectomy, lysis of extensive adhesions, enterolysis	Hysterectomy, BSO, pelvic tumor debulking	Cystoscopy	Grade 3 serous carcinoma of the fallopian tube	Optimal to no visible disease	200	362	2	None
2	54	37.2	Advanced	Total omentectomy, lysis of pelvic and upper abdominal adhesions	Hysterectomy, BSO, resection of pelvic implants	Cystoscopy	Grade 3 serous carcinoma, primary peritoneal	Optimal to no visible disease	100	306	2	None
3	50	36.2	Advanced	Total omentectomy, upper abdominal tumor debulking including tumor of hepatic flexure, and transverse colon, diaphragmatic stripping and ablation, appendectomy	Hysterectomy, BSO, pelvic tumor debulking, metastatic lymph node debulking	Cystoscopy, sigmoidoscopy	Grade 3 serous carcinoma of the ovary	Optimal to no visible disease	20	103	3	None
4	75	29.3	Advanced	Total omentectomy, diaphragmatic biopsy	Hysterectomy, BSO, resection of pelvic tumor metastasis, anterior and posterior cul de sac tumor debulking and culdectomy, resection of rectal tumor	Cystoscopy, sigmoidoscopy, inguinal lymph node dissection	Grade 3 serous carcinoma of the ovary	Optimal to no visible disease	400	477	6	None
5	70	27	Advanced	Supracolic omentectomy, upper abdominal and diaphragmatic debulking	Tumor debulking of anterior cul-de-sac and rectosigmoid, hysterectomy, LOA, enterolysis, peritoneal biopsies	Cystoscopy sling procedure	Grade 3 serous carcinoma of the ovary	Optimal to no visible disease	150	454	17	Bowel perforation
6	55	29.1	Recurrent	Aspiration of ascites, lysis of adhesions, enterolysis	Appendectomy, para-aortic lymphadenectomy, tumor debulking		Grade 3 clear cell carcinoma of the ovary	Optimal to no visible disease	100	252	1	None
7	53	32.9	Recurrent	Diaphragmatic biopsy (second look)	Pelvic and para-aortic lymphadenectomy, lysis of adhesions, peritoneal biopsies.	Cystoscopy	Grade 3 serous carcinoma of the ovary	N/A	100	226	2	None
8	39	25	Recurrent	Peritoneal biopsies, diaphragmatic biopsy, aspiration of ascites, upper abdominal tumor and diaphragmatic tumor debulking	Pelvic tumor debulking, lysis of adhesions.	Cystoscopy, sigmoidoscopy, insertion of IP port	Grade 1 mucinous adenocarcinoma of the ovary	Optimal to less than 0.5 cm	100	317	3	port-site cellulitis, peritoneal vaginal fistula

Table 2 (continued)

Case	Age	BMI	Disease status	Procedure			Pathology	Status of cytoreduction	EBL	ORT	LOS	Complications
				Laparoscopic	Robotic	Other						
9	70	35.4	Recurrent	Omentectomy, appendectomy	Lysis of extensive pelvic adhesions, upper vaginectomy, pelvic tumor debulking, peritoneal biopsies	Cystoscopy	Grade 3 serous carcinoma of the ovary	Optimal to no visible disease	100	212	1	None
10	63	27.5	Recurrent	Lysis of severe upper abdominal adhesions, resection of porta hepatis mass, cholecystectomy, supracolic omentectomy	Pelvic and para-aortic lymphadenectomy, lysis of adhesions, peritoneal biopsies	Cystoscopy	Grade 3 serous carcinoma of the ovary	Optimal to no visible disease	50	322	3	None
11	82	22.1	Advanced	Infracolic omentectomy	Hysterectomy, BSO, bilateral pelvic lymphadenectomy, appendectomy	Cystoscopy	Grade 3 serous carcinoma of the ovary	Optimal to no visible disease	100	238	2	None

BMI body mass index, *EBL* estimated blood loss, *ORT* operating room time, *LOS* length of stay, *BSO* bilateral salpingo-oopherectomy, *IP port* intraperitoneal port, *FIGO* International Federation of Gynecology and Obstetrics

Among the 11 cases operated for advanced and/or recurrent ovarian cancer, the mean age was 63.9 years (range, 39–92), average BMI was 29.7 kg/m^2 (range, 22.1–37.2), EBL was 129.1 ml (range, 20–400), operating room time was 238 min (range, 103–477), and LOS was 3.8 days (range, 1–17). In this group, surgical procedures consisted of six hysterectomies, five oophorectomies, eight omentectomies, three pelvic lymph node dissections (average, 10.7; range, 4–18), three para-aortic lymph node dissections (average, 5; range, 1–9), four appendectomies, five diaphragmatic biopsies, four upper abdominal debulking or diaphragmatic debulking, and one resection of a porta hepatis mass (Table 2; case 10; Fig. 4). Five patients had received neoadjuvant chemotherapy (Table 2; cases 2, 3, 4, 5, and 11). Of the 11 procedures, there was one second look (Table 2, case 7), 9 were cytoreduced to no visible disease and 1 to less than <0.5 cm. There were no intraoperative complications.

There were three postoperative complications; two were grade 1 and one was grade 3. Two complications (both grade 1) occurred in the same patient; one being port-site cellulitis and the other a peritoneal vaginal fistula. Both were managed conservatively with antibiotic therapy and observation. The peritoneal vaginal fistula was revealed by leakage of peritoneal ascites. The other patient was reoperated on postoperative day 3 for a sigmoid colon perforation which required reoperation and was discharged home on day 17 (Table 2; case 5). This case was the only Intensive Care Unit admission in both early and advanced groups.

Of all the patients operated on, there were no trocar site metastases within the follow-up period. However, one patient developed trocar metastasis beyond 30 days postoperatively and had recurrent intraperitoneal disease.

Discussion

Laparoscopy offers multiple advantages over laparotomy such as better visualization, smaller incisions, shorter hospital

Fig. 4 Porta hepatis mass attached to the gallbladder that has been resected laparoscopically, with cholecystectomy

stays, decreased blood loss, less need for analgesics, more rapid recovery, and shorter interval to chemotherapy and radiation when indicated. In the assessment of an adnexal mass and early-stage ovarian cancer, laparoscopy can be both diagnostic and therapeutic. The combination of laparoscopic visualization and frozen section analysis is the most reliable method for the detection of malignancy [15]. Once malignancy is diagnosed, comprehensive surgical staging can be performed laparoscopically, which has been shown to be feasible, safe, and accurate in tumors of low malignant potential and invasive early-stage disease [16–19]. Furthermore, in select cases of localized disease, it can be used to perform fertility-sparing surgical staging [14].

Minimally invasive surgery has emerged as an option in the management of advanced or recurrent ovarian cancer with multiple applications that have been presented in the literature [5, 20–22]. This includes a triage tool for resectability, primary and secondary cytoreduction, second-look evaluation, and placement of intraperitoneal catheters for chemotherapy [23].

In the early 1990s, the pioneers of laparoscopic surgery applied minimally invasive surgical techniques to gynecologic cancers for the staging of early and select cases of advanced or recurrent ovarian cancer cytoreduction [24, 25]. Since that time, the role of minimally invasive surgery in gynecologic oncology has been continuously expanding and has even been further applied to other disease sites in the female genital tract.

The advent of computer enhanced telesurgery or robotic-assisted surgery has seemingly presented itself as a new alternative to conventional laparoscopy. It offers the benefits of improving the learning curve associated with conventional laparoscopy, and other additional features, such as optimal visualization and a wider range of motion for more precise surgical manipulation. Yet, this innovation currently presents with limitations in the surgical management of patients with malignancy. Conventional laparoscopy offers a better understanding of the status of the disease, while robotic-assisted laparoscopy presents as an innovation in offering precise surgical motion and visualization of the disease process. However, this comes at the cost of some key elements required with surgical management, which are possible with conventional laparoscopy.

One such limitation is the lack of haptics, which may lead to missing tumor entirely or the ability to discern between normal tissue and tissue that is involved with carcinoma. Further limitations are in accessing all four abdominal quadrants simultaneously in one surgical setting and completing comprehensive surgical evaluation and treatment for patients with ovarian malignancy. This hybrid technique is presented to overcome these challenges, and the limited manipulation that exists with robotic-assisted surgery with the current platform. This is particularly true with limitations encountered when manipulating bulky tumor and tissue, such as that of the rectosigmoid with the present robotic platform and instruments.

The hybrid technique described offers advantages that are inherent to conventional laparoscopy for management of ovarian cancer. One limitation is the need for a second setup of a conventional laparoscopy in addition to the robotic platform. In our experience, it is customary to use this setup as an adjunct to robotic-assisted surgery. Conventional laparoscopy is used for port placement, in preparation of robotic-assisted laparoscopic surgery, thus making this setup not an additional component. Thus, using this method offers an extension of the use of conventional laparoscopy, while retaining the same port setup for pelvic surgery and utilizing conventional laparoscopy to operate cephalad to the pelvis.

Another inherent benefit is that conventional laparoscopy can also be used as an initial checkpoint in triaging for resectability based on the extent of disease and surgeon experience with robotic-assisted surgery versus other conventional methods. The conventional laparoscopy setup can also be further utilized after completion of robotic-assisted surgery to survey the abdomen and pelvis for any potential injury caused by the robotic instruments not detected due to the blind spot of the robotic camera and lack of haptics. Studies are lacking with innovative methods or strategies to counter this limitation of upper abdominal access with pelvic surgery when using the robotic platform. With advanced laparoscopic skills, this method facilitates the limitations of the robotic platform. An added advantage of using this method is enhanced visualization of surgical planes that require fine dissection in the pelvis due to prior surgery or disease involvement in the pelvis. In the upper abdomen, conventional laparoscopic methods can be utilized for limited disease, with this as the initial portion of the surgery, thus reducing surgeon fatigue (of the primary surgeon).

This technique also extends to novice surgeons who are aided by tactile feedback that conventional laparoscopy extends. However, it has its limitations in more challenging skills that are more easily afforded with robotic assistance (i.e., suturing, controlling bleeding, etc.). In comparison to other described techniques for accessing the upper abdomen, this method is less cumbersome and can be used in settings with residency and fellowship training programs that have bedside assistants who are less experienced. One complication reported with use of the alternate technique of placing the robot tower at the patient's head was conversion to laparotomy in order to access bleeding from the descending branch of the inferior mesenteric artery that could not be reached by the bedside assistant or the surgeon [9]. The access afforded in operating cephalad with use of this technique is not hindered in our experience. This technique has widespread application for use, and is versatile with the level of experience required by surgical assistants.

Minimally invasive surgical staging, more specifically cytoreductive surgery, are time-consuming procedures that are associated with surgeon fatigue that ensues with the course of the procedure. This method offers the benefit of conventional laparoscopy at the beginning of the case followed by the robotic-assisted portion of the procedure, which can help in the reduction of surgeon fatigue during the course of these lengthy procedures. This is an added benefit when the skill of an expert laparoscopist is needed for challenging initial portions of the procedure in the upper abdomen and then for more difficult portions with pelvic disease site affection in the latter portion of the procedure.

One issue that has to be addressed is the cost-effectiveness of the initial investment in the robotic platform relative to the cost of performing laparotomy, conventional laparoscopy, or robotic hybrid technique. Although only well-designed randomized studies will be able to adequately address this issue, presently, it is rather difficult to establish such a study in early and advanced ovarian cancer. In Wright et al. [26], the cost of robotic-assisted radical hysterectomy was least expensive comparative to laparotomy and even laparoscopy, due to shorter hospital stay. We believe that the use of this modality will allow more patients to be managed by a minimally invasive approach and thus reduce the number of laparotomies.

In summary, minimally invasive surgical techniques are consistently furthered from conventional laparoscopy to computer-enhanced telesurgery (also known as robotic surgery), and eventually to more compact devices that provide greater surgical precision with versatility in accessing all four abdominal quadrants more readily. Our technique serves as an interim improvisation to counter the limitations that exist with the present robotic platform.

Successful maximum cytoreductive interperitoneal metastatic disease in advanced ovarian cancer has been associated with the best outcomes [23]. However, this technique is not always possible and it carries significant morbidity. In randomized clinical trials, neoadjuvant chemotherapy followed by cytoreductive surgery has been shown much more effective in decreasing morbidity without compromising oncological outcomes [13]. Another benefit of neoadjuvant chemotherapy is that by reducing the bulky tumor, the chance of achieving optimal cytoreductive surgery by minimally invasive approach is greatly increased.

It has been our experience that using this hybrid technique, of a combination of conventional laparoscopy and the present robotic platform has been effective in the management of early, advanced, and recurrent ovarian, fallopian tube and peritoneal cancer while gaining the advantages of both technical approaches.

Conflict of interest The authors declare that there are no conflicts of interest.

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