Role of Minimally Invasive Surgery in Ovarian Cancer

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ABSTRACT

The standard treatment of ovarian cancer includes upfront surgery with intent to accurately diagnose and stage the disease and to perform maximal cytoreduction, followed by chemotherapy in most cases. Surgical staging of ovarian cancer traditionally has included exploratory laparotomy with peritoneal washings, hysterectomy, salpingo-oophorectomy, omentectomy, multiple peritoneal biopsies, and possible pelvic and para-aortic lymphadenectomy. In the early 1990s, pioneers in laparoscopic surgery used minimally invasive techniques to treat gynecologic cancers, including laparoscopic staging of early ovarian cancer and primary and secondary cytoreduction in advanced and recurrent disease in selected cases. Since then, the role of minimally invasive surgery in gynecologic oncology has been continually expanding, and today advanced laparoscopic and robotic-assisted laparoscopic techniques are used to evaluate and treat cervical and endometrial cancer. However, the important question about the place of the minimally invasive approach in surgical treatment of ovarian cancer remains to be evaluated and answered. Overall, the potential role of minimally invasive surgery in treatment of ovarian cancer is as follows: i) laparoscopic evaluation, diagnosis, and staging of apparent early ovarian cancer; ii) laparoscopic assessment of feasibility of upfront surgical cytoreduction to no visible disease; iii) laparoscopic debulking of advanced ovarian cancer; iv) laparoscopic reassessment in patients with complete remission after primary treatment; and v) laparoscopic assessment and cytoreduction of recurrent disease. The accurate diagnosis of suspect adnexal masses, the safety and feasibility of this surgical approach in early ovarian cancer, the promise of laparoscopy as the most accurate tool for triaging patients with advanced disease for surgery vs upfront chemotherapy or neoadjuvant chemotherapy, and its potential in treatment of advanced cancer have been documented and therefore should be incorporated in the surgical methods of every gynecologic oncology unit and in the training programs in gynecologic oncology. Journal of Minimally Invasive Gynecology (2013) 20, 754–765 © 2013 AAGL. All rights reserved.

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DISCUSS

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Ovarian cancer is the fifth most common cancer in women in the United States. The American Cancer Society estimated that in 2012, epithelial ovarian cancer would be diagnosed in >21 000 women and that >15 500 would die of the disease. The risk of a woman developing ovarian cancer is 1:70. More than a half of affected women are aged ≥65 years at diagnosis, and most are white [1]. Ovarian cancer is extraordinarily difficult to diagnose at an early stage because of the insidious nature of its symptoms and lack of markers and tests for early detection. Subsequently, ovarian cancer typically is not diagnosed until it is in stage III or IV. Early stages of the disease are diagnosed in only 15% to 20% of women, and in these patients the prognosis is much better, with 5-year survival >90%. Histologic features of the disease in these patients are primarily endometrioid and clear cell carcinomas, with a background of endometriosis [2,3]. In most patients with typical stage III disease, the 5-year survival rate is 46% [4]. Most lesions in these patients are poorly differentiated serous carcinomas, and although the term implies that the ovary is the site of origin, recent

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The standard treatment of ovarian cancer includes upfront surgery with intent to accurately diagnose and stage the disease and to perform maximal cytoreduction, followed by taxanes and platinum–based combination chemotherapy in most patients [6]. Surgical staging of ovarian cancer traditionally has included exploratory laparotomy with peritoneal washings, hysterectomy, salpingo-oophorectomy, omentectomy, multiple peritoneal biopsies, and possible pelvic and para-aortic lymphadenectomy. When preservation of fertility is desired and the disease seems to be confined to 1 ovary, preservation of the uterus and contralateral ovary is often possible.

In the early 1990s, pioneers of laparoscopic surgery used minimally invasive techniques to treat gynecologic cancers, including laparoscopic staging of early ovarian cancer. In selected cases, laparoscopic primary and secondary cytoreduction was reported [7–9]. Since then, the role of minimally invasive surgery in gynecologic oncology has been continually expanding, and today advanced laparoscopic techniques are used to evaluate and treat cervical and endometrial cancer. The important question about the role of the minimally invasive approach in surgical treatment of ovarian cancer remains to be evaluated and answered. Overall, the potential role of minimally invasive surgery in ovarian cancer is in the following categories: i) laparoscopic evaluation, diagnosis, and staging of apparent early ovarian cancer; ii) laparoscopic debulking of advanced ovarian cancer; iii) laparoscopic assessment of feasibility of upfront optimal surgical cytoreduction; iv) laparoscopic reassessment in patients with complete remission after primary treatment; and v) laparoscopic assessment and cytoreduction of recurrent disease.

**Laparoscopic Evaluation, Diagnosis, and Staging of Apparent Early Ovarian Cancer**

Early ovarian cancer is defined as cancer limited to 1 or both ovaries corresponding to FIGO stage I. Traditionally, staging surgery has been performed via a vertical midline incision, which provides excellent exposure of the upper abdomen, diaphragmatic surfaces, and pelvis. Meticulous surgical staging leads to upstaging in 16% to 35% of presumed early-stage ovarian carcinoma [10].

Several retrospective and case series reports have demonstrated the feasibility and safety of a laparoscopic approach in management of early-stage ovarian cancer [11–15]. These studies have shown that laparoscopy is associated with perioperative benefits such as decreased blood loss, faster return of bowel function, and shorter hospital stay. In addition, the studies have supported the concept that laparoscopy may offer an advantage in management of early-stage ovarian cancer by enabling better visualization of difficult areas such as the anterior abdominal wall, sub-diaphragmatic areas, peritoneal surfaces, obturator spaces, and anterior and posterior cul-de-sacs, as well as magnification and detection of smaller lesions that may be missed at perioperative imaging and even during laparotomy. Retrospective evidence in early ovarian cancer has revealed similar recurrence rates after laparoscopic and open staging procedures, suggesting that the laparoscopic technique does not compromise the outcome of early-stage ovarian carcinoma [14].

Nezhat et al [15] have reported a case series of 36 patients with presumed early-stage adnexal cancers who underwent laparoscopic staging/restaging. The lesions included 20 invasive epithelial tumors, 11 borderline tumors, and 5 non-epithelial tumors. The mean number of peritoneal biopsies was 6, of para-aortic nodes was 12.23, and of pelvic nodes was 14.84. Eighty-three percent of patients underwent laparoscopic omentectomy. At final pathologic analysis, lesions were upstaged in 7 patients. Postoperative complications included 1 small bowel obstruction, 2 pelvic lymphoceles, and 1 lymphocele cyst. Three patients had recurrence of disease. At mean follow-up of 55.9 months, all patients were alive without evidence of disease. That study represents one of the largest series, with the longest follow-up, of laparoscopic staging of early-stage adnexal tumors and illustrates that laparoscopic staging of these lesions, when performed by gynecologic oncologists experienced in advanced laparoscopy, seems to be feasible and comprehensive without compromising survival [15].

Tumor rupture during laparoscopic surgery to treat early ovarian cancer is of great concern. Although not proved in prospective studies, intraoperative tumor rupture will lead to immediate upstaging of the disease and may cause spread of tumor cells, compromising the prognosis. Although these concepts and observations seem logical, the ultimate test via randomized clinical trial is needed to determine whether the outcomes of laparoscopic and open surgical staging of early ovarian cancer are equivalent. Considering the low incidence of early ovarian cancer and the rapid changes in technology, it is questionable whether such study will be initiated. At present, all efforts should be made to reduce the incidence of tumor contamination of the abdominal cavity, including liberal use of a laparoscopic bag and controlled aspiration, and minimizing the risk of rupture [16].

**Minimally Invasive Surgery for Cytoreduction of Advanced Ovarian Cancer**

There is a paucity of data on laparoscopic cytoreductive surgery for advanced ovarian cancer. The first report of successful videolaparoscopic cytoreduction of advanced ovarian cancer was a case series that included 3 patients, all of whom underwent successful total laparoscopic primary or secondary cytoreduction [8].

In 2010, Nezhat et al [17] reported a series of 32 patients with advanced ovarian, fallopian tube, or primary peritoneal cancer who underwent laparoscopic evaluation for debulking. In 17 of the 32 patients, the disease was successfully
debulked at laparoscopy, with 88% of optimal cytoreduction. At mean follow up of 19.2 months, 9 patients were without evidence of the disease. Compared with the group who underwent laparotomy, the laparoscopic approach had resulted in minimal blood loss and a shorter hospital stay. No patients developed port-site metastasis, and time to disease recurrence in the laparoscopic group was not inferior to that in the laparotomy group.

In another retrospective series of 25 patients with presumed stage III/IV primary ovarian cancer undergoing laparoscopic-assisted cytoreduction, Fanning et al [18] reported successful cytoreduction in 23 patients (92%). Two procedures were converted to laparotomy because of extensive omental disease and bulky metastasis surrounding the rectosigmoid colon, respectively. In all 25 patients, the lesion was cytoreduced to <2 cm, and 36% had no residual disease. Median operative time was 2.3 hours, and blood loss was 340 mL. Median length of stay was 1 day. Median visual analog scale pain score was 4, which was discomforting. Six patients (24%) had postoperative complications; however, none were grade 3 or 4. Median overall survival was 3.5 years. The authors concluded that laparoscopic cytoreduction for primary advanced ovarian cancer can be successful and result in minimal morbidity and acceptable survival [18].

Hand-Assisted Laparoscopy

Krivak et al [19] reported 25 patients with ovarian carcinoma who underwent surgical staging and cytoreduction via hand-assisted laparoscopy. Six patients had apparent advanced ovarian cancer at referral, and of the 19 patients with presumed early-stage cancer, the disease was upgraded in 5 patients on the basis of retroperitoneal lymph node involvement. In 3 the disease had metastasized to other pelvic structures, and 2 had microscopic disease in the omentum. Twenty-two surgical procedures were completed via hand-assisted laparoscopy, and 3 procedures required conversion to laparotomy for completion of debulking. Operating time was variable, ranging from 81 to 365 minutes. Mean hospital stay was 1.8 days for the 22 patients who underwent successful hand-assisted laparoscopic evaluation. Complication rates were low, with 3 complications requiring repeat operation or hospitalization. The authors concluded that hand-assisted laparoscopy may be applicable in the initial management of early-stage and advanced ovarian carcinoma, enabling thorough evaluation of peritoneal and retroperitoneal structures and surgical cytoreduction, with the advantages of minimally invasive surgery [19].

Robotic-Assisted Laparoscopy

Recently, there have been reports of use of robotic-assisted surgery in patients with advanced ovarian cancer. In a retrospective case-control study, Magrina et al [20] compared 25 patients with ovarian cancer undergoing a robotic-assisted approach with 27 similar patients undergoing conventional laparoscopy and 119 undergoing laparotomy. In the respective groups, 60%, 75%, and 87% of patients were found to have FIGO stage III/IV disease, and the remaining patients had FIGO stage I/II disease. Mean estimated blood loss was 164 mL vs 267 mL vs 1307 mL (p < .001), and length of hospital stay was 4 vs 3 vs 9 days (p < .001), both significantly less in the robotic-assisted and conventional laparoscopic group compared with the laparotomy group. Node counts were similar in the 3 groups. Operative time was significantly longer in the robotic-assisted group, 315 vs 254 vs 261 minutes (p = .009). Overall survival was similar in the 3 groups, 67.1% vs 75.6% vs 66.0% (p = .08). The rates of intraoperative and postoperative complications were similar in the 3 groups. Patients were also subdivided and compared according to the extent and number of major procedures. The authors concluded that in patients undergoing primary tumor excision of epithelial ovarian cancer alone or with 1 additional major surgery, robotic-assisted and videolaparoscopy are preferable to laparotomy. They also concluded that overall survival is not influenced by the type of surgical approach but by the extent of debulking (complete vs incomplete). Similar to the report by Nezhat et al [17], no patients in the robotic-assisted or laparoscopy groups developed port-site metastases, which they believed was likely due in part to early initiation of chemotherapy.

Laparoscopic Assessment of Feasibility of Upfront Optimal Surgical Cytoreduction

The mainstay of treatment for advanced invasive epithelial ovarian cancer is ideally cytoreduction to no visible disease (microscopic) followed by platinum-based combination chemotherapy [6], which is associated with the best survival [21–24]. However, cytoreduction to microscopic disease is not possible in all patients at the initial surgery. To increase the rate of complete or optimal debulking and to limit perioperative morbidity, neoadjuvant chemotherapy with interval cytoreduction has emerged as an alternative to primary surgery [25]. This strategy does not seem to compromise survival, in particular if surgery is performed early, within 42 days of completion of neoadjuvant chemotherapy [25, 26]. Therefore, the primary issue is how to best evaluate the optimal resectability of advanced ovarian cancer. Despite improvements in computed tomography, magnetic resonance imaging, and positron emission tomography [27] and in tumor markers, resectability of intraperitoneal disease remains difficult to determine. Several predictive models have been proposed on the basis of clinical findings, imaging [27], and CA125 serum concentration; however, false-positive rates range from 5% to 37% [28], and therefore addition of surgical laparoscopic evaluation can be useful [29].

To assess resectability of advanced ovarian cancer, patients should be selected with the goal of achieving optimal primary cytoreduction, ie, no visible disease or microscopic disease. Laparoscopy has been used to assess the status of
disease and the possibility of cytoreduction before laparotomy [17,30]. In a recent clinical trial, it was proposed that laparoscopy be introduced as a triage technique at the start of surgical treatment to determine resectability and avoid suboptimal laparotomic debulking surgery [31]. We suggest and have been using the following approach in patients with presumed advanced ovarian cancer. The patient is evaluated clinically and by imaging techniques. Those who are found to be possible candidates for optimal cytoreduction undergo exploratory laparoscopy. On the basis of the surgeon’s surgical experience and the disease stage and performance status, optimal cytoreduction can be achieved using either laparoscopy, laparotomy, or a combination of both. Patients with disease that is too extensive for surgical optimal cytoreduction will undergo neoadjuvant chemotherapy (Fig. 1).

Recent compelling data have shown the feasibility of neoadjuvant chemotherapy followed by debulking surgery in the treatment of advanced ovarian cancer. In a prospective, randomized, controlled trial of 632 eligible patients, Vergote et al [25] showed that in patients with bulky stage IIIC/IV ovarian carcinoma, platinum-based neoadjuvant chemotherapy followed by interval debulking was not inferior to primary debulking surgery followed by platinum-based chemotherapy. Median overall survival was 29 months in the primary surgery group, compared with 30 months in the primary neoadjuvant chemotherapy group. Median progression-free survival was 12 months in both groups. That study also confirmed the importance of complete resection of all macroscopic disease in both groups, ie, primary debulking and primary neoadjuvant chemotherapy followed by interval debulking. When analyzed with respect to residual tumor, in both groups overall survival was inversely proportional to the amount of residual tumor after surgery, regardless of whether the patient underwent primary surgery or received primary neoadjuvant chemotherapy followed by interval cytoreduction. Overall survival in patients who underwent primary debulking surgery followed by chemotherapy with no residual tumor was 45 months, in those with residual tumor 1 to 10 mm was 32 months, and in those...
with residual tumor >10 mm was 26 months. Overall survival in these 3 groups who underwent neoadjuvant chemotherapy was 38, 27, and 25 months, respectively. Thus that trial confirmed the importance of optimal surgical cytoreduction regardless of whether surgery is performed before or after neoadjuvant chemotherapy. Therefore, we believe that in selected cases in which neoadjuvant triage is offered to patients and the disease after completion of chemotherapy is less extensive, laparoscopic debulking surgery may be performed (Fig. 1).

Laparoscopic Reassessment or Second-Look Surgery

In the past, second-look surgery was suggested as part of the therapeutic triage in patients with advanced ovarian cancer. Today this procedure is performed primarily in clinical trials or in selected cases with uncertain clinical response of patients. The minimally invasive approach had been used in second-look assessment in patients with a complete clinical response to platinum-based combination chemotherapy. Disease recurrence after negative second-look surgery was reported to be similar for laparoscopy and laparotomy, with laparoscopy having the advantages of less morbidity, shorter operative time, shorter hospital stay, and lower total hospital charges [32].

Laparoscopic Assessment and Cytoreduction of Recurrent Disease

The role of secondary cytoreduction surgery to treat recurrent ovarian carcinoma is debatable. Recently, several authors have suggested some criteria including isolated recurrence, lack of ascites, and optimal debulking at the primary surgery as indications for secondary debulking [33,34]. In these selected cases, laparoscopic secondary cytoreduction has been reported in case reports and series, with acceptable results insofar as efficacy and outcomes [8,35–38] (Fig. 2). Trinh et al [36] reported on 36 consecutive patients with asymptomatic chemosensitive stage III/IV ovarian cancer who had previously undergone debulking via laparotomy followed by chemotherapy, and when CA 125 concentration was elevated, underwent laparoscopic debulking. Preoperative abdominal/pelvic computed tomography yielded normal findings. Operative laparoscopy was performed using an open technique in the left upper quadrant, and tumors were debulked laparoscopically using the loop electrosurgical excision procedure and argon beam coagulation. Of the 36 patients, laparoscopic debulking was successful in 34 (94%), without requiring laparotomy. Of those 34 patients, all visible disease was resected at laparoscopy in 32 (94%), and surgical complications occurred in 2 patients (6%). Median operative time was 2.6 hours, median blood loss was 70 mL, and median hospital stay was 1 day. Seventy-four percent of patients had a complete response after laparoscopic debulking and chemotherapy, with a median progression-free survival of 1.1 years. The authors concluded that laparoscopic debulking using the loop electrosurgical excision procedure and argon beam coagulation seems feasible (94%), successful (94%), and safe (complications in 6%) [36].

Nezhat et al [37] reported a retrospective analysis of a prospective case series of 23 patients with recurrent ovarian, fallopian tube, or primary peritoneal cancer who were deemed appropriate candidates for laparoscopic debulking. The patients underwent exploratory videolaparoscopy, biopsy, and laparoscopic secondary/tertiary cytoreduction between June 1999 and October 2009. Of the 23 procedures, only 1 was converted to laparotomy. Seventeen patients (77.3%) had stage IIIC disease at the time of initial diagnosis, and 20 (90.9%) underwent laparotomy for primary debulking. Median blood loss was 75 mL, median operative time was 200 minutes, and median hospital stay was 2 days. No intraoperative complications occurred. One patient (4.5%) had postoperative ileus. Eighteen patients (81.8%) with recurrent disease underwent optimal cytoreduction to <1 cm. Over a median follow-up of 14 months, 12 patients had no evidence of disease, 6 were alive with disease, and 4 had died of the disease. Median disease-free survival was 71.9 months. The authors concluded that in a well-selected population, laparoscopy is technically feasible and can be used for optimal cytoreduction in patients with recurrent ovarian, fallopian, or primary peritoneal cancer [37] (Fig. 2).

Surgical Technique

Conventional Laparoscopy

Closed or open transumbilical or left upper quadrant (Palmer point) entry using a Veress needle is used most often. A 0-degree laparoscope, and at times a 30-degree laparoscope, is used via a port placed 4 to 5 cm supraumbilically. We use three 5- to 12-mm ancillary ports in the mid–lower abdomen when the primary lesion is below the pelvic brim. Additional upper abdominal ports can be placed for extensive upper abdominal debulking. Pelvic washings are collected for cytologic analysis, and parietal and visceral peritoneal surfaces of the deep pelvis and middle and upper abdominal cavities are thoroughly inspected (Fig. 3, A–D). Any suspect growth is biopsied. In the case of normal visual exploration, random peritoneal biopsies are performed in the pouch of Douglas, pelvic and abdominal parietal peritoneum, paracolic gutters, hemidiaphragms, and mesentery. Small and large bowel can also be carefully inspected laparoscopically. Running the small bowel can be accomplished from the ileocecal valve to the ligament of Treitz using 2 atraumatic bowel graspers. When conservative treatment is considered, biopsy of the contralateral ovary is performed only in the case of suspect growth on imaging studies or at laparoscopy. In this context, dilation and curettage are performed so as not to miss a possible endometrial spread or a synchronous tumor [3]. Every attempt should be made to prevent rupture of a suspect adnexal mass in the abdomen,
including choosing unilateral adnexectomy rather than ovarian cystectomy, limited manipulation of the mass, use of non-traumatic graspers, and preventive coagulation to avert bleeding that may obscure identification of the cleavage planes. Additional safety measures include removal of the specimen exclusively using a laparoscopic bag and control of the bag integrity once extracted. Laparoscopy is intrinsically limited by the size of the port incisions. Even when the incision is enlarged, a puncture is required to remove large masses. If the puncture can be located within an endobag and the integrity of the bag is preserved, the procedure is considered safe and preferable.

To achieve an infracolic omentectomy, the patient is placed supine in a dorsal lithotomy position. The primary surgeon stands between the patient’s legs, with the first and second assistants standing on each side of the patient. The position of the primary surgeon can be changed depending on port placement and the tissue being manipulated or resected. The omentum is excised from the inferior margin of the transverse colon using a Harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, OH), a linear stapler, or any of the electrosurgical blood vessel sealing devices. The Harmonic scalpel and LigaSure technology (Covidien, Mansfield, MA) are superior for omentectomy because of minimal fume formation, ease and speed of use, and lack of protruding staple edges (Fig. 4, A and B). The omentum specimen can also be removed using an endobag.

In patients with extensive upper abdominal disease, it is our practice to place a 5- to 12-mm port in the middle to upper right side of the abdomen and a 5-mm port in the left upper abdomen. This position is also optimal for diaphragmatic ablation and stripping (Fig. 5, A and B), supracolic omentectomy, and resection of further upper abdominal disease. Diaphragmatic ablation can be performed using a CO₂ laser, PlasmaJet (Plasma Surgical, Ltd., Oxfordshire, UK) (Fig. 6, A and B), and argon beam coagulator. From this
position, the patient can be turned to the right for better visualization of the spleen or for further dissection or mobilization of the transverse or descending colon near the splenic flexure. This position is also optimal for dissection near the stomach, in the lesser sac, during splenectomy, and near the pancreas. If splenectomy is indicated, the short gastric vessels can be secured using Harmonic ultrasonic shears, LigaSure technology, surgical clips, and/or a stapler while gaining access to the lesser sac (Fig. 7, A and B) [37]. The

Fig. 3

(A) Isolated diaphragmatic lesion. (B) Diffuse diaphragmatic metastasis. (C) Extensive omental caking. (D) Diffuse peritoneal carcinomatosis.

Fig. 4

(A and B) Total resection of omental caking using the LigaSure device.

Fig. 5

(A) Diaphragmatic stripping of peritoneum using a grasper and harmonic scalpel. (B) Diaphragmatic stripping showing stripped away peritoneum and underlying muscle fibers.
spleen can then be mobilized from its attachments and ligaments. The splenic vessels can be cut and the spleen removed using the laparoscopic stapling device (Ethicon Endo-Surgery). The patient can be turned to the left for further dissection near the liver, porta hepatitis, and ascending colon. The position can be further manipulated to aid in bowel resection of the small and transverse colon.

Transperitoneal pelvic and/or para-aortic lymph node dissection is performed while the patient is in the Trendelenburg position. For pelvic lymph node retrieval, the primary surgeon stands on either side of the patient, facing the monitors, which are positioned on both sides of the patient’s legs. The first assistant stands across from the surgeon, and the second assistant is at the bottom of the table, between the patient’s legs. The peritoneum overlying the psoas muscle is incised from the round ligament to the base of the infundibular pelvic ligament. External and internal iliac vessels, their major branches, and the ureter are delineated, and the avascular spaces are developed. After delineation of the anatomy of the pelvic sidewall, sampling or complete removal of all nodal packets along the external and internal iliac vessels and the obturator fossa is performed. Lymph nodes are retrieved through the suprapubic trocar sleeve (10–12 mm), avoiding contamination of the abdominal wall [16].

For para-aortic lymph node dissection, the room setup and trocar placement are similar as for pelvic lymphadenectomy, with the laparoscope introduced through the supravesical or suprapubic port. Pelvic operations such as hysterectomy, salpingo-oophorectomy, and any resection of metastatic disease are performed using the same ports as for pelvic lymph adenectomy [16].

**Robotic-Assisted Laparoscopy**

There are limitations when using the current computer-enhanced telesurgery called the robotic platform (Intuitive Surgical, Inc., Sunnyvale, CA) 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 enable performance of the procedure. The Society of Gynecologic Oncology consensus statement on robotic-assisted surgery commented that it is poorly suited for treatment of advanced ovarian cancer because of its limitation in gaining upper abdominal access with conventional trocar placement for pelvic surgery [39].

We have developed a hybrid technique in which both conventional laparoscopy and the robot are used in the surgical management of ovarian cancer. This surgical technique and

![Fig. 6](image)

(A) Hydrodissection over the diaphragm. (B) Diaphragmatic ablation using the PlasmaJet device.

![Fig. 7](image)

(A) Short gastric vessels are secured using the laparoscopic stapler while gaining access to the lesser sac during laparoscopic splenectomy because of metastasis to the parenchyma. (B) Splenectomy is performed using an articulating stapler.
its use in patients with early and advanced ovarian cancer is described as follows for laparoscopic management of both pelvic and upper abdominal disease.

An incision is made in either the left upper quadrant or 4 to 5 cm above the umbilicus, a Veress needle is introduced, and pneumoperitoneum is established. After adequate pneumoperitoneum is obtained, a 5- or 8-mm primary port is inserted in the left upper quadrant. If pneumoperitoneum is established supraumbilically, 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, and two 8-mm robotic ports are introduced 8 to 10 cm lateral to the umbilicus bilaterally (Fig. 8). Further peritoneal inspection is performed via conventional laparoscopy, and peritoneal washings or aspiration of any existing ascites are obtained and sent for cytologic analysis.

If there is disease in the upper abdomen and pelvis, surgery is begun using conventional laparoscopy to perform the omentectomy and upper abdominal debulking (Figs. 5–7). This is performed via use of the supraumbilical port for the camera and other ports for introduction of instruments. Any upper abdominal debulking is performed as described for conventional laparoscopy. This same approach can be used if there is no upper abdominal disease and only infracolic omentectomy is performed as part of surgical staging.

Any abdominal and pelvic adhesions that interfere with proper use of the robotic platform are lysed using conventional laparoscopy. After the upper abdominal portion is performed, the robotic apparatus is 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 artery is incised, and retroperitoneal dissection is completed cephalad to above the inferior mesenteric artery (Fig. 9). We use the electrosurgical spatula or scissors for cutting and bipolar forceps for achieving hemostasis. The left and right upper assist ports are used for introduction of ancillary instruments for traction, tissue removal, suction, and irrigation (Fig. 10). Pelvic lymphadenectomy, hysterectomy, salpingo-oophorectomy, and any tumor debulking are performed with the same instruments as used before or, at times, standard blood vessel sealing devices such as the LigaSure technology for ligation of the infundibular ligaments and hysterectomy (Figs. 11 and 12). If access to the para-aortic lymph nodes above the inferior mesenteric artery is not possible using the robotic platform, this portion of the operation is performed using a conventional laparoscopic approach after undocking the robot. In some instances, the location of the camera is moved from the supraumbilical port to the right upper abdomen to achieve this goal.

After the uterus is transected, it is removed from the vagina along with the omentum and any other specimens, which are confined to an endocatch bag. The vaginal cuff is closed in 2 layers. After complete hemostasis is achieved, the robotic apparatus is undocked. If hysterectomy is not being performed, all bulky specimens can be removed via a small mini-laparotomy using laparoscopic bags.

Cystoscopy is routinely performed to ensure that there is no damage to the bladder or bilateral ureters. The posterior cul-de-sac is filled with fluid and air is injected into the rectum to above the sigmoid colon to ensure that the bowel is intact. Trocars are removed and port sites closed in a routine manner.

In our experience in 20 women who underwent surgery using our hybrid technique of conventional laparoscopy and robotic-assisted laparoscopy, 21 surgical procedures were performed: 10 for early-stage disease, and 11 for advanced or recurrent disease (6 advanced and 5 recurrent). Of the 10 procedures for early-stage disease, mean patient age was 42.3 years (range, 29–55 years), body mass index

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**Fig. 8**
Port placement in hybrid technique.

**Fig. 9**
Robotic dissection exposes the bifurcation of the common iliac artery and mobilizes the right ureter laterally for para-aortic lymph node dissection.
was 32.1 (range, 17–65), estimated blood loss was 212.5 mL (range, 50–1000 mL), operative time was 306.1 minutes (87–639), and length of stay was 1.6 days (1–2). Mean number of pelvic lymph nodes dissected was 10.3 (range, 5–18), and of para-aortic lymph nodes dissected was 8.6 (range, 3–12). There were no intraoperative complications or intraoperative transfusions, and 2 postoperative complications. One patient was readmitted on postoperative day 9 because of a wound infection, and another was readmitted because of fever of unknown origin, which resolved with intravenous antibiotic therapy. Of the 11 patients operated on because of advanced and/or recurrent ovarian cancer, mean age was 63.9 years (range, 39–92 years), body mass index was 29.7 (22.1–37.2), estimated blood loss was 129.1 mL (20–400), operative time was 238 minutes (103–477), and length of stay was 3.8 days (1–17). Of these 11 patients, 1 underwent a second-look procedure. In 9 patients, disease was cytoreduced to no visible disease, and in 1 to <0.5 cm. There were no intraoperative complications or blood transfusions, but 3 postoperative complications. Two postoperative complications occurred in the same patient, which where port site cellulitis and a peritoneal vaginal fistula. The other patient underwent a second operation on postoperative day 3 because of a bowel perforation, and was the only patient admitted to the intensive care unit in either the early or advanced disease groups [40].

Upper abdominal primary cytoreduction can also be performed with the robot in reverse docking. This can be accomplished by undocking the robot, rotating the operating table, and redocking the robot at the patient’s head. Upper abdominal secondary cytoreduction in isolated upper abdominal recurrent disease can also be accomplished by docking the robot off of one of the patient’s shoulders, depending on the side of disease, using the same port placement as shown in Figs. 8 and 13A. Readjustment of the ports can be performed according to the pathologic findings.

Holloway et al [38] reported the case of a 60-year-old woman with recurrent platinum-sensitive ovarian cancer with an isolated 3.4-cm lesion noted on the dome of the right hepatic lobe at computed tomography and positron emission tomography. Upper abdominal tumor resection was accomplished by placing the patient in a 10-degree reverse Trendelenburg position, rotated to the left 10 degrees, and docking the robot over her right shoulder (Fig. 13B). During the operative procedure, adhesions from the liver to the diaphragm were separated, the hepatic lesion was excised, and diaphragmatic involvement of the cancer was noted. Full-thickness resection of the diaphragmatic lesion was performed, and the diaphragm was closed primarily using running No. 1 polypropylene (Prolene) suture. Estimated blood loss was 100 mL, total operative time was 137 minutes, and console time was 82 minutes. Pathologic analysis revealed margins and washings negative for disease. There were no important intraoperative complications.
Cytology-negative pleural effusion developed, which was successfully drained via thoracentesis on postoperative day 4, and subsequently chemotherapy was started at 4 weeks postoperatively (Fig. 13, A and B).

Bowel resection can be performed at 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 through 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 used for segmental transverse colon resection and reanastomosis to achieve optimal cytoreduction. 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 gastrointestinal anastomosis 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 or a lower middle incision, or transvaginally along with the specimen. An anvil can then be placed and secured using a purse string suture. The anvil and proximal sigmoid colon are then brought back into the pelvis, and an end-to-end anastomosis can be performed using a 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 using a bowel grasper, filling the pelvis with lactated Ringer solution, 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 [37].

In conclusion, with the continued advancement in endoscopic techniques and instrumentation, laparoscopy has emerged as a feasible alternative to open laparotomy in managing gynecologic malignant disease. The minimally invasive surgical approach and its use in ovarian cancer diagnosis and treatment continues to evolve and broaden.

Accurate diagnosis of suspect adnexal masses, the safety and feasibility of this surgical approach in early ovarian cancer, the promise of laparoscopy as the most accurate tool for triaging patients with advanced disease for surgery vs upfront chemotherapy or neoadjuvant chemotherapy, and its potential for treatment of advanced cancer are documented and therefore should be incorporated in the surgical arsenal of every gynecologic oncology unit and training programs in gynecologic oncology. The potential role of minimally invasive surgery in advanced and recurrent ovarian, fallopian tube, and primary peritoneal cancer are described in Figures 1 and 2.

The promise of minimal incisions and shorter recovery time, coupled with an increased number of skilled laparoscopic surgeons and a team approach in well-equipped operating rooms, add to the potential of introducing these approaches in ovarian cancer treatment without the context of a clinical trial. However, women with ovarian cancer and our clinical field would be best served if our collective effort is focused on designing and conducting randomized phase III clinical trials to adequately and definitively address these clinical situations.

Until now, surgery followed by chemotherapy has been the standard treatment of advanced-stage ovarian cancers. However, this has not significantly improved survival and prognosis in these women. The future depends on finding the different developmental pathways of this disease, finding appropriate chemotherapy and biological agents, targeting specific tumor cell types, and individualizing therapies. The majority of ovarian cancer can be treated medically instead of surgically and in the future, if surgery does play a role, it will not be as aggressive as it is today.
References


