Chapter 12

# Robotic Surgery in the Management of Endometrial Cancer

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Additional information is available at the end of the chapter

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**Abstract**

Endometrial cancer remains the most common gynecologic malignancy in the Unites States and Western Europe. It has been estimated that in 2014, about 52, 630 new cases of endometrial cancer was diagnosed and about 8,590 died from the disease. Prior to 1988, endometrial cancer was staged clinically. Since that time surgical staging has been adopted. With the advancement in technology, the vast majority of cases are being staged and treated surgically via minimally invasive approaches. Conventional laparoscopy has been a major advancement in staging and treatment of uterine cancers. However, technical challenges such as 2–D imaging, rigid instruments, and lack of precision and surgeon fatigue did not translate into widespread adoption of this technique. With the advent of computer–enhanced robotic telesurgery, this has dramatically changed the surgical management and staging of endometrial cancer.

**Keywords:** Endometrial cancer, robotic surgery, oncology, surgical techniques, outcomes

## 1. Introduction

Endometrial cancer is a general definition that often includes all cancers that develop in the uterus, the most common being endometrioid cancer, or cancers arising in the lining of the uterus or endometrium.[1-3] In the United States, endometrial cancer is the fourth most common cancer among women and also the most common gynecological cancer, with on average about 6% of all female cancers.[4] In the United States, the number of new cases estimated to be diagnosed in 2015 is about 55,000 based on data from the American Cancer Society. Of note, the number of deaths based on these data is expected to be roughly 10,000, with death rates rising between 0.8% and 1.9% per year within the last 5 years.[2] However, there is quite a notable variation in worldwide incidence. For example, the highest incidence is observed in Western Europe, United States, and Canada, while in comparison, Africa and Asia are shown to have the lowest rates of incidence.[5] The overall increase in the incidence of this disease during the last decades is mainly related to higher life expectancy within the developed world.[5]

Endometrial cancer is often described as principally a menopausal state disease, since the majority of the cases occur in advanced age.[4, 5, 6, 8] The risk of endometrial cancer increases with the age of the woman. The median age of diagnosis is around 61 years, with the peak incidence happening between 55 and 70 years old. Data from the research community show that most cases, about 95%, occur in patients over 40 years of age with only up to 5% of disease development occurring in women younger than 40.[9-11] Interestingly, the median age of death is around 73 years.[11] The majority of cases are postulated to be of a sporadic etiology, although there is a minority with evidence of a hereditary basis. A number of research articles have been published detailing the correlation of increased risk of endometrial cancer occurrence in women from families with the autosomal dominant hereditary non-polyposis colorectal cancer (HNPCC) gene. Importantly, endometrial carcinoma is the most common extra-colonic cancer seen in this condition referred to as Lynch syndrome.[6, 12] The lifetime risk in these women is about 40% to 60%, and they have a risk of about 40% of developing endometrial cancer by 70 years old.[6, 11, 13]

A unifying theme among the risk factors is that of increased estrogen exposure.[92] The gradual growth in incidence especially within the last decade also has some correlation with dietary and hormonal factors.[14] Obesity, along with increased abdominal girth, is a known risk factor.[2, 15, 72-73] There has been a notable worldwide increased prevalence of obesity. It appears from some data that developed countries are more disproportionately affected by this phenomenon. Increased body mass index (BMI) is also suggested to result in a higher all–cause mortality and endometrial cancer–specific mortality in endometrial cancer survivors.[16-17] By contrast, Park et al looked at the relation of pre-treatment BMI on known prognostic factors, the impact of disease–free survival, and the cause–specific survival in a recent Korean study of women with endometrial cancer. The study population results, however, found that BMI was not a significant factor for both disease-free and cause-specific survival.[18] Of note, endometrial cancer is the third most common gynecological cancer in Korea. A Swedish cohort study of 11659 women evaluated various lifestyle factors including diet and physical activity and possible association of risk of endometrial cancer. Overall, 133 cases of endometrial cancer were observed. The data suggested that an increased risk was noted with very low intake of fruits and vegetables and statistically significant decreased risk ($p < 0.01$) with increased physical activity.[19] Increased weight in early adult life as well as middle age also increased the risk. The management of peri– and postmenopausal symptoms by unopposed exogenous estrogen is yet another risk factor.[20-21]

Risk factors often associated with decreased risk of endometrial cancer are those that help to decrease the amount of circulating estrogen. These include oral contraceptive (OCP) use, intrauterine device (IUD) use, and cigarette smoking. OCPs have been shown to lower the risk by up to 40%, with protection still noted up to 15 years after last use. A proportional correlation is seen with protection and length of use.

Although the exact etiology still remains elusive, it is known that most cases arise from atypical hyperplasia of the lining of the uterus.[72-76] Epithelial cancers of the uterus are generally divided into two groups. Type I endometrial cancers make up 75% – 90% of endometrial cancers and are usually low grade, diagnosed in early stages with good prognosis and of endometrioid histology. They are estrogen–dependent and tend to develop in an environment of hyperplasia or unopposed estrogen exposure, whether physiological or pharmacological. In addition, this subset may have phosphatase and tensin homologue mutations. Type II endometrial cancers, however, are estrogen–independent, usually high grade, have a poor prognosis, often diagnosed at later stages and are usually of papillary serous, clear cell, or even high-grade endometrioid pathology. Type II cancers may have a link with P53 tumor suppression mutation and the endometrial milieu of Type II cancers is often associated with polyps or simply atrophic in nature.

At diagnosis, the malignancy is frequently found to be localized or within the borders of the uterine corpus in 72-75% of instances, especially since they present early with abnormal uterine bleeding.[11, 15] As mentioned earlier, the chance that postmenopausal bleeding is a result of cancer substantially escalates with a woman's age. Endometrial cancer is usually diagnosed in early stages, although up to 20% of patients with clinical stage I may have indications of extrauterine spread at time of surgical intervention.[22] The relative estimated survival rates at the 5- and 10-year mark are approximately 82% and 79%, respectively.[2]

## 2. Surgical management

Although not the focus of this chapter, initial evaluation and workup is usually achieved via endometrial biopsy and ultrasound. Abnormal uterine bleeding is often the most common presentation that is seen. Current recommendations from the American College of Obstetricians and Gynecologists and other governing bodies still recommend the evaluation of all patients with postmenopausal bleeding for likelihood of endometrial cancer. In addition, any female over the age of 40 years with abnormal bleeding should also be evaluated. This evaluation consists of obtaining tissue either by an endometrial biopsy or dilatation and curettage.

After histologically confirmed diagnosis, additional evaluation to rule out metastasis may be considered. A chest radiograph may be helpful to note any simultaneous pulmonary disease or involvement and to rule out possible metastases to the lung.[13] In some cases, the measurement of CA-125 is also obtained because in some women with advanced stage disease at time of diagnosis, CA-125 usually may be elevated. These elevated levels can help in determining adequate response to treatment or recurrence of disease during post–treatment surveillance.[23-24] However, for the typical histology of Type I, endometrioid Grade 1 and clinical stage 1 patient, a physical examination and chest X-ray is usually only required.

In the majority of cases, the subsequent step involves surgery for definitive treatment, staging to determine the extent of the disease, and to reduce tumor burden in advanced stages with extrauterine disease. In 1971, the International Federation of Gynecology and Obstetrics (FIGO) put forth a comprehensive clinical staging system, which was used worldwide.[25] This initial step helped to standardize to some degree the diagnosing and relevant treatment of the disease. However, since 1988, clinical staging has mainly been replaced by surgical staging especially since it does not fully evaluate significant histopathological features. [22, 76-78] The Gynecologic Oncology Group (GOG) carried out two large–scale prospective trials looking at surgical staging in 1984 and 1987.[22, 26] The results from these studies aided in determining the important prognostic factors along with indicated treatment goal. Along with age, race, and endocrine status, it was shown that prognosis is related to the presence or absence of certain uterine and extrauterine risk factors. Uterine factors include histologic type, grade, depth of invasion into the myometrium, isthmus-cervix extension, and lymphovascular space invasion. Extrauterine factors include adnexal metastasis, intraperitoneal spread, positive peritoneal cytology, pelvic and aortic node metastasis, and estrogen/progesterone receptor activity. [27] FIGO stage is often considered to be the single strongest predictor regarding outcome in endometrial cancer based on results from various multivariate analyses.[28]

Current staging is based on the FIGO 2009 staging criteria.[25-26, 29-31] The procedure of surgical staging includes an adequate evaluation of the peritoneal contents, peritoneal cytologic washings, hysterectomy, bilateral salpingo-oophorectomy, cytoreduction of all visible disease, and bilateral pelvic and para-aortic lymph node dissection.[11, 13] Ideally, the procedure should entail the same components whether done via a laparotomy or by minimally invasive surgery (MIS). In the instance where a patient is unable to undergo surgery, whole pelvic and intracavitary radiation may be used as definitive treatment. However, some data have shown a notable decrease in 5-year survival times for clinical stage 1 disease treated in this maner (67%) compared to surgery alone (87%).[11]

## 3. History of laparoscopy in management and staging of endometrial cancer

The introduction and involvement of laparoscopy has become truly integral and beneficial in management of endometrial cancer. For more than 30 years, gynecologic surgeons have used laparoscopy for many procedures, including oophorectomies, ovarian cystectomies, and bilateral tubal ligations. Earlier research studies published information on both the feasibility and technique of radical hysterectomy with pelvic and para-aortic lymphadenectomy.[32-35] These helped set the foundation for the possibility of full and comprehensive surgical staging using an MIS approach. Of note, laparoscopic intervention would not get its introduction into the field of gynecologic endometrial cancer until the earlier part of the 1990s. A 1992 publication by Childers et al.[36] was the first to report on laparoscopically–assisted vaginal hysterectomy (LAVH) for management of endometrial cancer based on two cases. The case report also mentioned techniques such as port placement, insufflation methods, and lymphadenectomy involving pelvic and para-aortic nodes. In a subsequent study series, Childers et al. published data involving the first use of laparoscopy in surgical staging of endometrial cancer.[37] The data showed a total of two conversions to laparotomy in their population (*n*= 59), with most common indications being complications such as transected ureter and incidental cystotomy. Interestingly, additional deductions from this study were that this new technique appeared to have similar operating times to conventional laparotomy, however, with an increased degree and length of learning curve for surgeons. Another study looked at the utility of LAVH and laparoscopic lymph node dissection with supporting results of association of decreased postoperative pain and blood loss with increased lymph node yield. Yet this study did show increased operating time compared to open surgery.

Since the initial case reports and other similar retrospective studies done around that time, the development and advancement of minimally invasive laparoscopic methodologies to the surgical staging of endometrial cancer has continued. Later studies have included multiple variables such as description of feasibility reports of the standard laparoscopic method, outcome analysis of open surgical versus laparoscopic techniques, analysis of cost-effectiveness, and even development of laparoendoscopic single-site surgery (LESS).[37-46]

## 4. History of robotics in gynecologic surgery

The natural progression in medicine, and science and technology, tends to show that with new research comes novel breakthroughs. This is evidenced in a wide variety of procedures, algorithms, medications and in this case equipment. More often than not, these tend to be helpful in the advancement of the art of medicine. This effect is seen directly with the establishment of robotic surgery in the field of gynecologic surgery. We have clearly seen a revolution in the armada of gynecological interventions with MIS over the last three decades.[47] The field of robotic surgery has undergone rapid advancement, especially in gynecology, [7-8], since it was originally developed for medical and surgical use in battle zones. The goal was that robotic surgery could be used by surgeons in a remote location to perform simple or complex procedures with similar skill, technique and outcomes as if done in a regular operating room.

There are earlier models that helped to pave the way for the advanced systems currently in use and lead to development in the field and technique. One such model and the first robot to assist in a surgery was a single robotic arm known as Automated Endoscopic System for Optimal Positioning (AESOP) developed by Computer Motion Inc. (Computer Motion, Inc., Santa Barbara, CA, USA).[48-49] Cleared by the Food and Drug Administration (FDA) in 1994, this device was made to hold and manipulate an endoscope and remove the need for an assistant. In addition, it was designed to give a surgeon improved control over visualization and also allow command over the laparoscope using voice-activation.[50] The first commercially available robotic system, ROBODOC, described in 1992 was a robotic arm designed for use in orthopedic hip prosthesis surgery[49], and allowed for accurate incisions in the femur bone for implant insertion. In 1998, Computer Motion Inc., marketed another model that had been in development called ZEUS Surgical System (ZSS), which had a 2-D imaging system and robotic arms made to mimic the surgeon's arms. Two arms were added to the AESOP to create the ZEUS. The arms also allowed for downscaling of movement from the surgeon's hands and elimination of tremors. The surgeon sat at a console, which helped to decrease fatigue especially in longer operations and expanded on the possibility of telesurgery or remote location surgery.

**Figure 1.** Da Vinci Surgical System with additional training console

Another company, Intuitive Surgical, Inc. (Intuitive Surgical, Mountain View, CA, USA) also developed a robotic surgery assist model called the Da Vinci Surgical System (DVSS) shown in Image 1.[91] Unlike the ZSS, the DVSS used a 3–D vision system produced from two endoscopes, which results in a perceptual 3–D image. It also was designed with the EndoWrist system, which offered seven degrees of freedom. This resulted in the recreation of the dexterity and range of motion of a surgeon's hand, therefore allowing a high degree of accuracy and flexibility. Instruments could thus also be rotated a full $360^0$.[51] The first successful surgery was done in 1997 in Belgium.[52] The DVSS was eventually cleared by the FDA in 2005 for use in gynecologic procedures and has full regulatory clearance with the coveted Conformité Européenne (CE) mark in Europe.[53]

## 5. Advantages of robotic surgery

Even with the initially high cost of acquisition (estimated between 1– and 2 million U.S. dollars) of a DVSS for an institution, there are many advantages of robotic surgery that make it worthwhile. More than 7,000 peer–reviewed publications have been published on

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computer–enhanced robotic surgery. For example, the amount of clinical evidence and data on the robotic surgery system and technique is increasing at a rate of 100 publications per month on average.[54]

### 5.1. Dexterity

The invention of the ergonomic wrist instruments allowed for more accurate replication of the movement at the wrist, including rotation.

### 5.2. Precision

The robotic surgical system provides the ability to improve the precision with which the surgical procedure is carried out. This is due in part to different factors such as the EndoWrist concept, tremor reduction (explained below), and improved field of view.

### 5.3. Field and depth of view

The ability to see in a 3–D image as mentioned earlier is truly a remarkable feature. As an old adage of excellent surgical techniques, the need for adequate exposure and visualization is vital. This is also one improved quality over the laparoscopic technique, which has a limited 2–D view. In addition, robotic surgery does have the benefit of greatly increased magnification which adds ability for more precise fine microsurgery techniques. The robotic setup that includes a viewing station for the assistants and other staff in the room provides both a great interactive learning and teaching viewing option unique to this system.

### 5.4. Control and motion dampening

This technology was also seen in the earlier Zeus system. It gives the ability to reduce the tremors created naturally by the extension of the fingers or the resultant tension due to fatigue as operating times increase. This is somewhat similar to being on a cruise ship and not feeling the rocking of huge waves but just that gentle back and forth enough to give the calm feeling of being at sea. However, the robot is able to filter out unnecessary hand and finger motions which results in safer, more accurate intracorporeal movements.

### 5.5. Decreased blood loss

This can be seen as a direct result of the factors above, especially greater instrument control, viewing ability, and small entry sites.

### 5.6. Learning curve

Studies have looked at the required learning to be proficient in both laparoscopic and robotic techniques, with the latter often noted to be less difficult to acquire. This is due to the ergonomic setup and more counter-intuitive hand movements needed compared to a laparoscopic style. It is suggested that 20 robotic procedures are needed for proficiency.[55-56] Operative times tend to decrease and the nodal counts increase with increased surgeon's experience.

### 5.7. Decreased surgeon fatigue

The surgeon operator console provided on the robotic surgical system is a great enhancement, especially in longer operations. [57]

## 6. Techniques of robotic surgery

The use of port sites and the selection of these ports are important in MIS. As mentioned earlier, the actual technique of staging should ideally be the same regardless of type of abdominal incision.

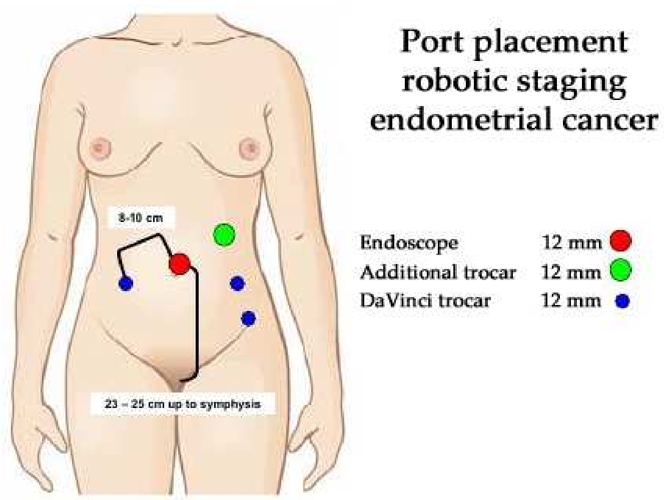


**Figure 2.** Schematic demonstration of the port placement in robotic assisted operation for endometrial carcinoma

Techniques include either single-site port or multiple port use and other factors play a role in determining which the best approach is used.

**Figure 3.** Pelvic lymph node retrieval

Our patients undergo a bowel prep regimen. Patients are positioned securely on a foam memory pad with Velcro straps placed across the breasts. This is critical for the $29^0$ Trendelenburg position for the entire case. Patients are placed in lithotomy in Allen stirrups. A uterine manipulator is used in the majority of cases. Typically, 5 ports are placed as shown in the diagram, Figure 1.[58] The camera is placed approximately 25 cm above the pubic symphysis. The robot is then docked from the patient's left side. A $0^0$ scope is used. The fenestrated bipolar and the monopolar hot shears are used as the operating instruments.

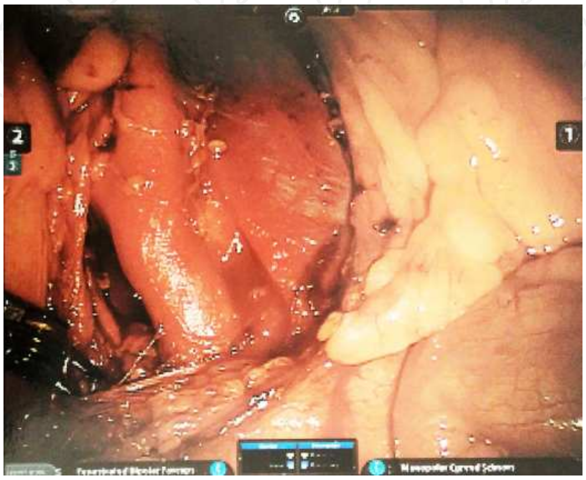

**Figure 4.** Para-aortic lymph node retrieval.

During indicated lymphadenectomy, pelvic and/or para–aortic, adequate dissection is essential. The robotically assisted system and technique help with improving node yield. The following images shown are during lymph node harvesting for both the pelvic and the para-aortic lymph nodes during cases at our institution. Image 2 shows the intraoperative dissection and removal of nodes in the pelvic cavity, while Image 3 shows the dissection and removal of para-aortic nodes. In Image 3, the aorta is seen on the left of the image (top-down view) branching into the right and left common iliac arteries.

## 7. Comparison of outcomes between open surgery and MIS

Total laparoscopic hysterectomy was compared to total abdominal hysterectomy in the LACE trial.[59] In this trial, there was notable improvement in quality of life for up to 6 months for the participants. Also, on that trial, there were more frequent serious adverse outcomes in the laparotomy versus the laparoscopy group.

The largest randomized prospective multicenter study to evaluate outcomes between open surgery and MIS is known as the Gynecologic Oncology Group (GOG) LAP2 trial, a 10-year data accrual study.[60] It compares outcomes between incidence of surgical complications, perioperative morbidity and mortality in stage I or IIa, grades I to III endometrial/uterine cancer in patients being staged with either traditional laparotomy approach versus comprehensive laparoscopic staging. The GOG in this trial aimed to evaluate the feasible role of a laparoscopic method in the primary surgical treatment of endometrial cancer in terms of staging rates, safety, recurrence, and survival. In that study, the rate of conversion to open surgery was 26%. The reasons for conversion were poor visualization, extrauterine spread and bleeding. It was noted that as the BMI increased, so did the rate of conversion. With a BMI of less than 20, the success rate was 90% compared to 34% with a BMI of 50. The median number of lymph nodes harvested was not significantly different. The complications were also evaluated. In the LAP2 study, the hospital time was 2 days in laparoscopic group compared to 4 days in the laparotomy group. The oncologic outcomes of the comparison were reassuring. The estimated 5–year survival rate was 11.6% and 13.7% for laparoscopy and laparotomy, respectively. The overall survival rate was essentially equivalent between the two groups at 89.8% at 5 years.

There have been many retrospective and other studies comparing outcomes and complications between laparotomy and robotic/laparoscopic surgery.[79-81] The key differences between the two are outlined below.

### 7.1. Estimated blood loss

The use of smaller multiple incisions compared to a larger incision portends to an expected decreased blood loss. In addition, the magnification and ability to control small blood vessels contributes significantly to the decreased blood loss noted. In a study by Gaia et al. comparing outcomes in laparotomy versus laparoscopic techniques, outcomes were similar except for a statistically significant reduction in blood loss favoring the laparoscopy group. However, there was no difference in transfusion rates.[61] In other studies, however, robotic surgery was associated with reduced blood loss and transfusion when compared to conventional laparoscopy.[53]

### 7.2. Length of operating time

Operating time has been shown in studies to be shorter in open surgery compared to MIS. Some studies suggest that operating time was on average 30 min longer for laparoscopic procedures.[59] In the LAP2 trial, operative was longer for laparoscopy by about a median of 70 min.[60] To some degree, this also is based on surgeon expertise with MIS and potential limitations with instrumentation. Some of these limitations are overcome by the robotic platform.

### 7.3. Increased exposure/visualization

Laparotomy may seem to have increased exposure simply due to the large abdominal incision created during the procedure. However, with the magnification obtained during laparoscopy visualization is superior, especially in the deep pelvis.

### 7.4. Length of Hospital Stay (LOHS)

Due to smaller incisions with minimally invasive techniques, faster expected healing and recovery time are seen in MIS compared to open surgery. This results in decreased need for prolonged admission after operation. As an example, in the LAP2 trial, hospital time was shorter, 2 days with laparoscopy compared to 4 days with laparotomy.[60] He et al. [62] in a meta–analysis noted shorter length of hospital stay (mean difference [MD], -3.42; 95% confidence interval [CI], -3.81 to -3.03; $p < 0.01$) with laparoscopy compared to laparotomy. Other studies have also demonstrated similar results regarding decreased LOHS with laparoscopy.[60, 63-65]

### 7.5. Lymph node yield

Various studies including the previously mentioned GOG LAP2 trial have focused on lymph node yield in either approach. Some studies have shown a similar amount of nodes sampled or retrieved while others have shown increased on either side. Also, in the 2013 meta–analysis of nine randomized controlled trials by He et al., the data showed no statistically significant difference between either approach pelvic node yield (MD, 0.45; 95% CI, -0.41 to 1.32; $p = 0.30$).[62]

### 7.6. Complications

In the GOG LAP2 trial, which remains the largest prospective randomized trial comparing laparoscopy to laparotomy in the management of endometrial cancer, the combined complication rate inclusive of vascular, urinary, bowel, and nerve was higher in the laparoscopy patients (10%) in comparison to the laparotomy group (8%).[60] DeNardis et al. have however shown reduced complications in robotic cohorts. In that study, major peri–operative complication was found to be 3.6% in the robotically-assisted cohort compared to 20.8% in the laparotomy group.[66]

## 8. Comparison of robotic surgery versus conventional laparoscopy in endometrial cancer

These two techniques are both types of MIS, although one can often think of robotic surgery as being the younger, more advanced sibling. In this way, robotic surgery in many ways has helped to enhance the techniques and outcomes involved in laparoscopic surgery. Two areas of note where this unique edge is definitely appreciated is in the treatment of both the elderly and the obese with endometrial cancer. These two conditions require additional concern due to possibility of co–morbidities, access, and post–operative survival and outcomes. Cho and Nezhat in their review of 754 case identified complication rates of 10.5%, 12.2%, and 44.6% in robotic hysterectomy, laparoscopic hysterectomy, and abdominal hysterectomy, respectively. [67] In the open cohort, the majority of complications were related to wound infections and bowel dysmotility. There was also a lower rate of conversion in the robotic group when compared to the laparoscopic group. The above–mentioned advancement in the robotic system is no doubt responsible for this observation.

### 8.1. Decreased Estimated Blood Loss (EBL)

Decreased blood loss is seen in many studies comparing the two techniques with robotic being associated the lesser amount. In Seamon's study, estimated blood loss was 100 and 250 mL, respectively, for robotic versus conventional laparoscopy.[68]

### 8.2. Decreased Length of Hospital Stays (LOHS)

Especially in the current medical climate with current societal economic situations, the trend is to improve the proper utilization of resources while, at the same time, decreasing costs wherever possible. Although robotic surgery comes with a substantial investment cost, having shorter hospital admissions especially postoperatively can help to reduce operating costs from a different angle. Studies have shown either similar in some cases or usually a slightly decreased LOHS in robotic surgery.[68]

### 8.3. Decreased Operating Room (OR) time

This is related to surgeon skill, experience and expertise. Since robotic surgery has been shown to have an improved learning curve, this may play a role in overall operating time. Also, coupled with the other benefits robotic surgery offers, this may result in faster times from incision to incision or from docking to incision in some studies. However, some studies have shown similar operating times between the two methods. Seamon et al. in their comparison of robotic to conventional laparoscopy reported reduced mean operative times in the robot group, 242 versus 287 min.[68]

### 8.4. Decreased chance of conversion to laparotomy

Some studies, both observational and retrospective comparison, have noted less chance for conversion with decreased visualization, body habitus, patient weight, and comorbidities often being reasons cited for having to do so. This occurs less in robotic than laparoscopic surgery. Gaia et al. demonstrated a 9.9% conversion rate in laparoscopy compared to 4.9% for the robotic approach.[61]

### 8.5. Patients with increased BMI

The prevalence of obesity is increasing. Obesity is associated with increased surgical morbidity. There is an associated increase in blood loss, operative times, wound complications, and venous thromboembolism. Hence, the development of newer techniques that will provide a comparable surgical staging with reduced morbidities is very attractive. The obesity factor affects both techniques but the qualities of the robotic surgery tend to lend toward decreased morbidity compared to laparoscopic surgery. Recall in the LAP2 trial that the success of surgical staging was decreased with increasing BMI. The robot seems to overcome this limitation associated with conventional laparoscopy. In a retrospective study by Gehrig,[69] complete surgical staging was accomplished in 92% of robotic patients in contrast to 84% in the laparoscopic group. Also notable was the shorter operative times (189 vs 215 min, $p = 0.004$, less blood loss (50 v 150 mL, $p < 0.001$) and a statistically significantly shorter hospital stay.

Another retrospective study done by Mendivil et al. comparing robotic, laparotomy, and conventional laparoscopic cohorts of morbidly obese patients (BMI > 40 kg/m$^2$) compared the outcomes of each procedure.[82] Robotic surgery had the longest operating time compared to laparoscopy and laparotomy (2.78 vs 1.82 and 1.35 h, $p < 0.001$) but had the least estimated blood loss respectively (100 vs 175 and 250 mL, $p = 0.002$). The length of hospital stay was significantly shorter with both minimally invasive methods compared to laparotomy (2 vs 4 days, $p = 0.002$)

### 8.6. Patients of advanced age

Elderly patients usually have more co–morbidities and are generally poorer surgical candidates with concomitant more advanced disease, which may require more surgical intervention. There have been studies looking at the utility of robotic surgery in this scenario, as well as laparoscopic surgeries. In a retrospective analysis by Scribner et al., laparoscopic staging was completed in 77.6% of patients. The operative time was increased for the laparoscopic group, however, there was no increased morbidity from longer anesthetic times.[70] Another study by Lavoue et al.[87] compared a population ($n = 113$) of advanced age patients (greater than or equal to 70 years) with endometrial cancer undergoing surgical staging by either robotic or traditional open surgery. The robotic group had longer operating times (244 vs 217 min, $p = 0.009$) but less estimated mean EBL (75 vs 334 mL, $p < 0.0001$), less minor adverse events (17 vs 60%, $p < 0.001$) and decreased mean LOHS (3 vs 6 days, $p < 0.0001$). However, no statistical difference ($p = 0.61$) was noted in the 2-year disease–free survival during follow-up.

A single institution retrospective chart review looked at the safety of robotic surgery in a cohort of patients with endometrial cancer ($n = 228$) compared to laparotomy.[88] The cohort was subdivided by method of surgery (robotic vs laparotomy) and age (<65 vs 65 years and older). Older patients undergoing robotic surgery had decreased estimated blood loss (131 vs 235 mL, $p = 0.03$), decreased rate of postoperative ileus (0 vs 15%, $p = 0.04$), decreased perioperative surgical complication rate (4 vs 30%, $p = 0.01$), and decreased LOHS (2.2 vs 4.4 days, $p < 0.01$) compared with laparotomy. The rate of discharge home was similar with compared to laparotomy (96 vs 91%, $p = 0.45$).

Robotic surgery with the associated advantages such as decreased EBL, decreased LOHS, and potentially decreased postoperative morbidity may show potential for improved outcomes compared to laparoscopic surgery and laparotomy. Further studies may be needed to evaluate this comparison.

### 8.7. Single-Port Access (SPA)

The progression from traditional open surgery toward minimally invasive methods, both robotic and conventional laparoscopic, has resulted in further innovation such as attempts at using fewer port entry sites, less trocars, and smaller abdominal incisions.

Laparoendoscopic single–site surgery (LESS), a novel technique, may lead to an additional decrease in the overall invasiveness of conventional laparoscopy. Fanfani et al.[83] in a 2012 publication of a single institution cohort trial looked at laparoendoscopic single–site surgery

(LESS) in surgical management of early–stage endometrial cancer. The results showed median age of 57 years (42–68), median BMI of 24 kg/m$^2$ (21–30) with median operating time of 105 min, and median EBL of 20 mL (10–180). The skin and fascial incision needed for this single-port access approach was 2.5 cm (median 2.2 cm, range of 2.0–2.5) with all patients reported being satisfied with both pain control postoperatively and the cosmetic results.

Some difficulties inherent with LESS include instrument crowding as well as clashing, decreased and/or poor visualization, loss of triangulation, and ergonomic issues.[85] The combination of robotic surgery with LESS may help to overcome some of the technical limitations noted with LESS. A retrospective case–control study by Fagotti et al. looked at the comparison outcomes between robotic and laparoendoscopic single–site hysterectomy for treatment of early endometrial cancer.[86] Although the median OR time was less in the robotic versus laparoendoscopic group (90 min vs 107 min), the data did not produce any seemingly clinically relevant differences.

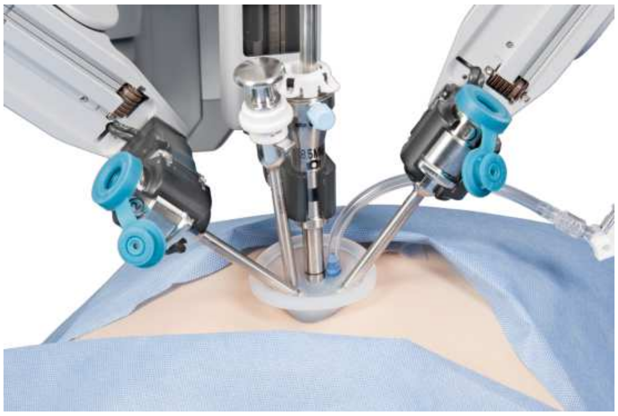

**Figure 5.** Single site port system

The robotic single–site port system[89] which enables operating through a small umbilical incision in common procedures such as benign hysterectomies, cholecystectomies, or salpingo–oopherectomies. The recommended size of incision needed for this five–lumen port (see Image 4[93]) is typically about 1.5 cm. As seen the port has five channels. There is a channel for the 8.5 mm scope, two robotic arms, a surgical assistant port, and an insufflation port. The instruments are semiflexible and capable of triangulation. Currently, the instruments lack the EndoWrist articulation, which might be disadvantageous. The advantages of this technique include the promise of potentially virtually scarless surgery due to the small incision, in addition to the known ones of robotic surgery such as decreased EBL and LOHS.[90] More prospective studies with larger numbers are needed to compare robotic single–site surgery with standard robotic multi-site surgery for procedures commonly done.

A pilot study published in 2013 by Vizza et al.[88] looked at the feasibility and safety of using robotic single-site hysterectomy in patients with low–risk early stage endometrial cancer. The five–lumen port described above was used with the size of the umbilical incision ranging from 2 to 2.5 cm. The median age was 64 years with a median BMI of 26.6 kg/m$^2$. The results showed

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median OR time to be 90 min, median blood loss of 75 mL with no reported conversion to laparoscopy or laparotomy, and median LOHS of 2 days. No reported complications occurred neither intra– nor postoperatively. The study concluded that robotic single–site hysterectomy was a safe and technically possible option in this patient group. Future studies with other gynecologic oncologic procedures and cases need to be carried out to evaluate the feasibility and advantages of this technique.

### 8.8. Cost

Any cost analysis of the different modalities of surgery and staging in endometrial cancer cannot overlook the impact of hospital stay on overall cost. Since the robot has been effective in shifting hysterectomy and staging to an essentially an outpatient procedure, there will be an anticipated decrease in overall hospital cost.

A cost effective analysis of robotically assisted management of new endometrial cancer was performed by Leitao et al.[71] The costs were inclusive of all surgical aspects of care provided up to 6 months following discharge. In that study, the total mean amortized cost per case was $20,487 for laparoscopy, 20,467 for robotically assisted, and $24, 642 for laparotomy. It was concluded that when laparotomy rates are reduced by virtue of the robot, then there is notable cost neutralization. A similar finding of laparoscopy being the least expensive approach was noted. Interestingly, if the cost of the robotic disposable instruments did not exceed $1,046, then from a societal perspective the robotic approach would be the least expensive.[46] In other studies, the utilization of the robot was deemed to be approximately 1.5 times higher than conventional laparoscopy. However, the mentioned reduction in completion of case and decreased conversion to laparotomy cannot be ignored.

Future studies will probably examine the use of the robot in debulking advanced cases of uterine cancers. Single–site surgeries will probably become more popular. Advancements in the actual technology are only expected to sky rocket. One can only imagine what the next step involves or what direction robotic computer-enhanced telesurgery would take. The important factor overall is being able to find that balance of effective patient care and management with the proper utilization of resources based on overall cost as well as reimbursement.

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