Chapter 1

Use of robotics in reproductive surgery

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Introduction

With increasing interest surrounding minimally invasive procedures, robotic-assisted laparoscopic surgery is becoming more prominent in gynecological surgery. Laparoscopy offers several benefits over laparotomy including shorter hospital stays and quicker return to normal activities. Patients undergoing laparoscopy also report less pain and utilize fewer narcotics postoperatively. Decreased blood loss and overall improved cosmesis are other attractive aspects of laparoscopic surgery. Despite the advances, however, limitations to laparoscopy do exist. Laparoscopic surgery requires a longer learning curve compared to laparotomy. Limitations exist with the degree of instrument movement and loss of depth perception [1]. Technology has made steps in overcoming the limitations of traditional laparoscopy with the development of robotic-assisted laparoscopic surgery.

Robotic surgical tools first appeared in operating rooms in the mid 1980s with the Programmable Universal Machine for Assembly (PUMA) 560 (Unimation), a device used to perform brain biopsies. Other early robotic models include the Automated Endoscopic system for Optimal Positioning (AESOP, Computer Motion) and the EndoAssist (Armstrong Healthcare). These two systems consist of simple robotic arms designed to hold and position laparoscopic cameras. Computer Motion then combined three AESOP robotic arms to create the ZEUS surgical system. The ZEUS utilizes a master and slave model of a robotic system with the surgeon seated at a master console controlling the slave robotic arms. This system improved upon some of the difficulties of traditional laparoscopic surgery with improved ergonomics, increased degree of instrument movement, development of three-dimensional (3D) imaging and provided a steady camera [2]. Of the previously mentioned robotic devices, the ZEUS was the first robotic system utilized in gynecological surgery [3]. The ZEUS disappeared from the commercial market, replaced by the robotic system used currently in gynecological surgery: the da Vinci immersive telerobotic system (Intuitive Surgical Inc.).

Robotic hardware

The da Vinci surgical system consists of three components: a surgeon's console, a patient-side cart with four interactive arms, and a vision cart. The surgeon operates via the surgeon's console positioned outside of the operating field. The surgeon sits in the console and possesses a 3D view of the operative field while controlling the camera and all interactive arms docked in the patient. The surgeon's fingers are placed in the master controller, and the system translates his or her hand movements into real-time movements of the surgical instruments docked in the patient-side cart (see Figure 1.1). The system allows for seven degrees of motion in the instruments that mimic the dexterity of the human hand and wrist (see Figure 1.2). The patient-side cart docks near the patient with one camera arm and two or three surgical arms positioned in the patient. It may be docked either between the patient's legs or in a side docked position next to the patient, an arrangement which gives improved access for uterine manipulation.

The surgeon experiences several benefits while utilizing the da Vinci surgical system. Improved ergonomics are achieved with the surgeon more comfortably seated at the surgeon's console. This prevents physician fatigue that might otherwise develop during lengthy laparoscopic procedures. Three-dimensional vision at the surgeon's console and enhanced contrast and magnification improve the visual field. The surgical system

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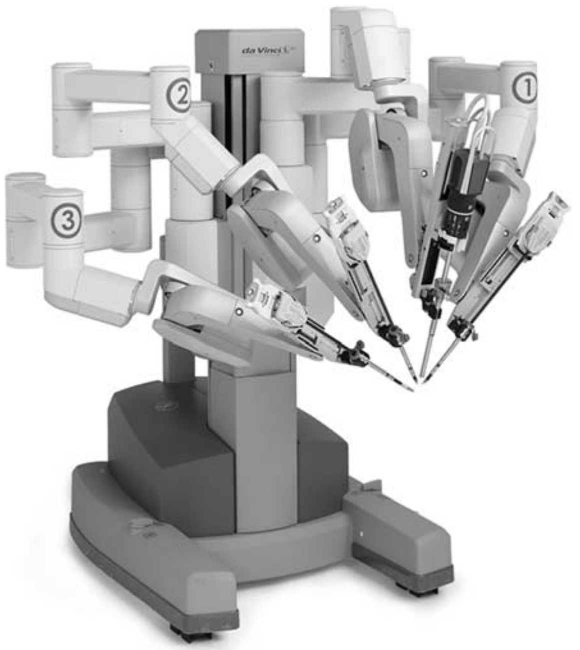

Figure 1.1. The patient side cart of the da Vinci Robotic System (courtesy of Intuitive Surgical).

Figure 1.2. The da Vinci endowrist device (courtesy of Intuitive Surgical).

also reduces hand tremor thereby improving surgical precision. Additionally, the fulcrum effect seen in traditional laparoscopic procedures disappears with the robotic system due to the fact that the robotic instruments move in the direction of your hands rather than the opposite direction.

Drawbacks to the da Vinci surgical system do exist. First, the significant amount of space taken up by the system limits its use to only larger operating rooms. Another negative aspect is the lack of tactile feedback, requiring the surgeon to rely on visual cues instead. At 1.5 million dollars each, the high cost of the robotic unit prevents widespread distribution. Also, the surgical system does not eliminate the need for operative assistants. Each surgery requires an assistant to change the robotic instruments. Also, a traditional laparoscopic port must be placed for use, through which the assistant retracts, suctions fluid and passes suture. Despite these limitations of the surgical system, the popularity of this device continues to increase in several surgical specialties including gynecology.

Furthermore, a learning curve exists for any new technology. This is not only true for the surgeon and surgical assistants, but also includes a learning curve for operating room support staff. Lehihan *et al.* reported the learning curve at their institution, studying primarily laparoscopic hysterectomies. They found that it took 20 cases for the OR team to be able to set the robot up for surgery in 45 minutes or less and it took 50 cases to improve this time to 35 minutes or less. Robot console time and total operative time became consistent after 50 cases with approximately 50 minutes needed for console time and 90 minutes needed for total operative time [4]. The technical challenges of this newer technology can be overcome with its repeated use and the aid of well-trained support staff.

Robotic-assisted laparoscopic surgery in gynecology

Use of robotics in general gynecology

After the initial emergence of the robot as a technology to assist minimally invasive surgery, more and more investigators started to amass data with respect to operative outcomes using this new innovation. No randomized clinical trials have been published, but many physicians have begun to publish case reports and retrospective comparisons on procedures done in general gynecology, urogynecology, gynecological oncology, and reproductive surgery.

Magrina *et al.* performed a retrospective comparison of 85 patients who underwent robotic adnexectomy with 91 patients who underwent similar laparoscopic surgery. Findings included statistically significant longer operating time for the robotic group, but not necessarily clinically significant, with a difference of approximately 10 minutes. There was no significant difference in blood loss, intraoperative, or postoperative complications between each group. Surgeon preference in this study gravitated towards laparoscopic removal of large masses due to greater ease of manipulation as well as trocar placement and drainage of masses. These authors also noted that staging could be performed more easily with a laparoscopic case because of the greater access to the upper abdomen that is not obtained without significant repositioning in a robotic case [5].

A different study retrospectively reviewed 100 patients undergoing total hysterectomy laparoscopically (pre access to the robot) compared with 100 patients undergoing hysterectomy robotically. Among the outcomes examined, operative time was also found to be longer overall in robotic cases, this time by 27 minutes. When the final 25 robotic cases of the series were compared with the time for laparoscopic cases, however, the robotic cases were actually shorter by 13 minutes. Time spent at the robot console also significantly decreased from an average of 105 minutes for the first 25 cases down to 49 minutes for the last 25 cases in the series, arguing for a significantly shorter learning curve for robotic surgery as compared to laparoscopic surgery. Another factor demonstrating a shorter learning curve with robotics is that the rates of abandonment of a minimally invasive procedure were higher in the pre-robotic group as compared to the robotic group (11% vs. 0%) as were intraoperative conversions to laparotomy (9% vs. 4%). The majority of conversions (both preoperative and intraoperative) were related to uterine size, with the authors noting the robotic group could tolerate a much larger uterine size before requiring conversion (1214 g vs. 259 g). Mean blood loss was almost twice as much for the laparoscopic group, although again this is potentially not clinically important (113 ml vs. 61 ml). Length of stay was 1.6 days for the laparoscopic group, compared with one day for the robotic group. Complications were minimal for each group. Of note, vaginal hysterectomies were also included in this study with surprisingly low numbers (6% of hysterectomies pre-robotics and 2% post-robotics), which may indicate that this study population was skewed towards laparoscopy [6].

Boggess *et al.* reported cases of 152 patients undergoing non-oncological hysterectomy with more complex pathology. Findings included operating times of 122 minutes, similar to Magrina *et al.* Surgeries were noted to take longer if the uterus weighed more than 250 g or if residents or fellows were involved. Estimated blood loss was 79 ml, length of stay was one day, and there were no conversions to open cases. They concluded robotic hysterectomy was possible while also achieving minimal blood loss, short hospital stay, and low complication rate. This study compared their robotic data with other major series reported by the time of publication, finding that operative time tended to be lower than other published reports, estimated blood loss was similar, as was length of hospital stay [7].

With any new technology come problems, and organized information regarding consistent complications is lacking. Kho *et al.* examined patients who had a vaginal cuff dehiscence after robotic hysterectomy (either simple or radical), trachelectomy, or upper vaginectomy. They found 4% of these patients experienced a vaginal cuff dehiscence, noted to be a full thickness separation of anterior and posterior vaginal cuff. This is a distinctly larger percentage of patients with this complication compared to hysterectomies by other means (abdominal and vaginal approaches). In this series, the colpotomies had been performed using monopolar coagulation, and the vaginal cuff was closed using nonlocking running sutures of polyglactin secured with absorbable clips. Average time to dehiscence was 6 weeks, and the precipitating factor was coitus in 10 of the patients [8]. Only one other study has shown a similar increased rate of vaginal cuff dehiscence with traditional total laparoscopic hysterectomies compared to abdominal or vaginal hysterectomies [9]. In fact, many reports and randomized clinical trials on laparoscopic hysterectomy do not show this increased rate of dehiscence [10]. Reasons for the potential increase in dehiscence rates for robotic or traditional laparoscopic hysterectomies may be related to delayed wound healing secondary to thermal dissection methods and other techniques used specific to laparoscopy. The true significance of this is unclear at this time as the Cochrane review by Johnson *et al.* comparing different surgical approaches to hysterectomies does not mention vaginal cuff dehiscence in their meta-analysis [10]. Larger prospective trials are needed to further address this potential complication.

Use of robotics in urogynecology

Urogynecologists have also started to adopt the new robotic technology, finding somewhat similar results. Three studies have examined short-term outcomes, long-term outcomes, and feasibility of robotic-assisted sacrocolpopexy. Considerable laparoscopic skill is required to complete a sacrocolpopexy with conventional laparoscopy, particularly given issues with visualization, suture placement, and managing intraoperative complications, especially bleeding. Inability to master these difficulties results in laparotomy. Ideally, the robot facilitates knot tying with the seven degrees of freedom the articulating instruments provide. For a case series of 77 patients undergoing da Vinci assisted laparoscopic sacrocolpopexy, conventional laparoscopy assesses the abdominal cavity, and when adequate visualization is obtained the robot is engaged. The remainder of the procedure is completed using the robot. Results showed complications including one conversion to laparotomy for bleeding (1.3%), seven patients with mesh erosion (9.1%), as well as other complications including cystotomy, enterotomy and ileus, each of which were 7% or less. No patients required transfusion, and mean hospital stay was only 2 days. In this series operative time also decreased from 188 minutes in the first 36 cases to 155 minutes for the last five cases. Assessment one year postoperatively showed approximately 5% of patients had pelvic pain, prolapse symptoms, or new incontinence, and 10% of patients had dyspareunia. Ninety-four percent of patients reported they would be willing to undergo the procedure again and were satisfied with results, which, combined with intraoperative results, indicates feasibility of robotic sacrocolpopexy [11].

Other published studies looking at robotic sacrocolpopexies have also shown similar promising results. A retrospective review of colpopexy done either robotically or abdominally for vaginal vault prolapse found robotic surgeries were associated with decreased blood loss (103 ml vs. 255 ml) and shorter length of hospital stay (1.3 days vs. 2.7 days) but also longer operating time by 100 minutes. The authors commented that when only colpopexies were analyzed, without other concurrent procedures, the blood loss was 69 ml in the robotic group compared with 412 ml in the abdominal group. Very minimal differences in POPQ scores were noted at the 6 weeks postoperative visit [12]. An additional urogynecology group investigated long-term outcomes of robotic sacrocolpopexy. In the course of their investigation, they noted time to complete the entire procedure robotically decreased by almost two hours after becoming accustomed to the technology. Only one conversion to laparotomy occurred due to dense adhesions prohibiting laparoscopic dissection. These patients were discharged on postoperative day one except for a single patient who left on postoperative day two. Minimal immediate postoperative complications were noted. At one year follow-up 95% of patients had no further problems. These authors concluded robotic sacrocolpopexy may offer the same benefits of long-lasting repair as the corresponding abdominal procedure and may benefit a population of patients who would otherwise be unable to undergo abdominal sacrocoplpopexies due to its lengthy operation and recovery [13].

Use of robotics in gynecological oncology

The gynecological oncologists perhaps have the most to gain by successful adoption and adaptation of robotic technology to previously existing procedures, given that so many oncological surgeries are done abdominally with significant morbidity and mortality. We will briefly review the use of robotics in gynecological oncology here.

Several studies have compared robotic-assisted radical hysterectomies to laparotomic procedures, reporting benefits of robotic-assisted radical hysterectomies. Significantly less blood loss and fewer complication rates have been noted when comparing robotic-assisted cases radical to open cases. Additionally, postoperative hospital stay is markedly decreased in the robotic group. In one study, postoperative hospital stay decreased from six days in open procedures to one day in the robotic-assisted procedures. As can be expected, longer operative times compared to open procedures have been found, but operating times have been shown to decrease with surgeon experience [14].

Both traditional laparoscopic radical hysterectomies and robotic-assisted radical hysterectomies have demonstrated benefits over open procedures in these comparison studies. A significant decrease in the length of postoperative stay and intraoperative blood loss for the laparoscopic and robotic groups as compared to the laparotomy group has been demonstrated [14]. Intraoperative and postoperative complication rates have been found to be similar or decreased in the robotic groups compared to open procedures. Additionally, comparable or superior lymph node sampling has been noted in patients undergoing a robotic-assisted procedure compared to an open one [15, 16]. When comparing traditional laparoscopic to robotic-assisted laparoscopic radical hysterectomies, operative time, length of hospital stay, blood loss, or bladder catheterizations have been found to be similar in some reports [17], while other studies have shown traditional laparoscopic surgery to be significantly longer than robotic-assisted [15]. This is probably due to the fact that as experience with the robotic system is increased, efficiency is gained, and the procedures can be performed in a timelier manner.

Endometrial cancer staging and hysterectomy is another area of gynecological oncology that has utilized robotic technology. Several studies have looked at the advantages and disadvantages of the robot for these procedures. Findings of decreased intraoperative blood loss and decreased hospital stay for robotic-assisted cases compared to open procedures have again been demonstrated for patients in this setting [18]. Boggess *et al.* compared patients undergoing hysterectomy and staging for endometrial cancer via three approaches: robotically, laparoscopically, and abdominally. Longest operating times were noted in the traditional laparoscopic group, followed by the robotic-assisted group then the abdominal group (213 min vs. 191 min vs. 146 min). Length of stay was similar for the robotic and laparoscopic groups (1 day, 1.2 days) in comparison to the longer hospital course after abdominal surgery (4.4 days). Blood loss was also lower in the robotic group compared with both laparoscopic and abdominal groups (74 ml, 145 ml and 266 ml respectively). Postoperative complications occurred more frequently in the abdominal group (29%) with wound separation and readmission for ileus being the most common [19].

The learning curve for robotic-assisted endometrial cancer staging and hysterectomy has also been investigated by Seamon *et al.* They found that the majority of robotic cases that needed to be converted to an open procedure occurred within the first 50 procedures. The authors concluded the major learning curve in performing robotic endometrial cancer staging was within the first 20 cases. They also noted that operative time increased approximately 8 minutes for every increase of 1 unit of body mass index (BMI), as did the likelihood of conversion to laparotomy [20].This group further analyzed their cases to detail the outcomes of obese patients undergoing endometrial cancer staging, an area of particular interest given the relationship between obesity and endometrial cancer. A retrospective chart review matched laparotomic and robotic staging procedures for endometrial cancer with patients with a mean BMI of 40. Each group had similar lymph node counts. The robotic procedure resulted in a lower estimated blood loss (109 vs. 394 ml), lower blood transfusion rate (2% vs. 9%), shorter length of stay (1 vs. 3 days), and fewer complications than the laparotomic procedures. The laparotomic procedures were significantly shorter than robotic procedures (143 vs. 228 minutes). The collective findings indicate that patients who are more likely to develop endometrial cancer based on their obesity may be more viable candidates for minimally invasive surgical treatment [21].

Minimal information has been published regarding ovarian cancer, although conceivably many of the advantages found with endometrial and cervical cancer could be applied to techniques managing ovarian cancer. Similarly, little information is available regarding use of the robot during pelvic exenteration. Schneider comments briefly on the feasibility of laparoscopic or robotic pelvic exenteration, noting that the most difficult portion of laparoscopic exenteration is the urinary diversion. Few studies have been reported using the robot for this specific purpose; however, he reviews two case series of urinary diversion which suggest the possibility of being able to perform an exenteration robotically. More research needs to be done to further explore robotic assistance with this procedure [22].

Use of robotics in reproductive surgery

One area in reproductive surgery in which robotic assistance has been utilized is in tubal ligation reversal surgery. Tubal sterilization is a popular permanent method of contraception. However, many women have been later plagued with regret over the decision to undergo surgical sterilization. A large, prospective, multi-center study in the United States found the cumulative probability of regret 14 years out from tubal sterilization to be 12.7%. The findings were even more dramatic for women who underwent the procedures at age 30 or younger. The 14 year cumulative probability of regret in the younger age group was found to be 20.3% [23].

Women with regrets from tubal sterilization generally have two options available to them: in vitro fertilization (IVF) or surgical reanastomosis. Tubal anastamosis is traditionally performed though a minilaparotomy incision utilizing microsurgical techniques. Traditional laparoscopic surgery became an option for some patients desiring this procedure, and has been shown to give equivalent pregnancy rates when compared to anastomosis done by laparotomy [24]. However, traditional laparoscopic instruments are not ideal for tubal anastomoses due to the precise microsurgical suturing that is required for success of this procedure. Robotic technology with its seven degrees of freedom and superior magnified visualization can facilitate the technically challenging microsurgical suturing.

Initial reports of robotic tubal anastomosis involved the Zeus robotic system (Computer Motion Inc.). The pilot study by Falcone *et al.* described the use of the Zeus robotic system for 10 patients desiring sterilization reversal. Nineteen fallopian tubes were successfully anastomosed and postoperative hysterosalpingogram demonstrated patency in 17 of the 19 tubes [4]. Five of the 10 patients subsequently achieved pregnancy within one year of surgery, carrying their pregnancies to term [25]. As previously stated, the Zeus robotic system is no longer commercially available.

Similar to the Zeus system, initial case series describing successful tubal anastomosis have been reported utilizing the current surgical robotic system on the market, the da Vinci system (Intuitive Surgical, Inc.) [26]. Furthermore, comparisons of tubal ligation reversals done with the assistance of the da Vinci system to those performed with traditional laparotomy have also been reported in the literature. Pregnancy rates have been found to be statistically similar between the two techniques with no difference in ectopic rates. Potential advantages noted in patients undergoing robotic tubal anastomosis include a decreased use of post-op analgesics and a shorter time to recovery. Specifically, a statistically significant decreased time to return to work has been found in patients undergoing robotic tubal anastomosis compared to patients who had laparotomy. However, total operative time and anesthesia time for the robotic procedures were found to be statistically longer when compared to the procedures done with an open technique. Additionally, operative costs with the robot are significantly increased [27, 28]. Continued advances in surgical robotic technology will help overcome these current limitations of robotic-assisted laparoscopic tubal anastomosis.

Another area in reproductive surgery in which the utilization of surgical robotics has been explored is in laparoscopic myomectomies. Myomas can be found in a variety of places within the pelvis, most commonly intracavitary, intramural, or serosal. The size and location of fibroids can cause a variety of symptoms for patients, and many patients may be asymptomatic. Frequently, fibroids are discovered in asymptomatic women during an infertility evaluation. Previous studies have demonstrated decreased pregnancy outcomes when myomas distort or obstruct the uterine cavity [29]. It is generally recommended to remove these distorting myomas to improve fertility outcomes. In many cases myomas that distort or obstruct the cavity can be removed by hysteroscopic resection. Not all, however, will be suitable for hysteroscopic resection and will need to be removed by laparotomy or laparoscopy. Specifically, myomas that are mostly intramural cannot be removed hysteroscopically. Controversy exists on the fertility effects of subserosal and intramural fibroids that do not distort or obstruct the endometrial cavity. A recent meta-analysis conducted a systematic review of the literature to better answer this question. This review by Sunkara *et al.* analyzed studies that compared IVF outcomes of patients with non-distorting intramural myomas to control patients. The analysis found that for patients with a non-distorting myoma there was a significant decrease in clinical pregnancy rates by 15% per IVF cycle and a significant decrease in live birth rate by 21% when compared to controls. No significant difference was found in implantation rate or miscarriage rate [30]. The decreased pregnancy rate and live birth rate found in this study would seem to support removal of these lesions prior to IVF. However, the meta-analysis did not address how the removal of these myomas would influence IVF outcomes. There are limited studies that look at the affects of myomectomies on fertility. One study that did look at fertility outcomes in patients before and after abdominal myomectomies for subserosal or intramural fibroids did find a significant decrease in pregnancy loss after myomectomy from 69% to 25% and a significant increase in live birth from 31% to 75% [31]. This would again support removal of non-distorting myomas for improved fertility outcomes. However, this was a relatively small and retrospective study. Prospective, randomized trials are lacking and are needed to clarify this controversial topic.

Furthermore, for patients who will undergo a myomectomy for intramural or subserosal myomas, a decision needs to be made on the appropriate surgical approach. Criteria used by our institution to select cases that are appropriate for intramural laparoscopic myomectomy include: uterine size of 15 cm or less, dominant fibroid is 15 cm or less, a total of five fibroids or less that need removal, and fibroid location excludes the broad ligament or cervix. MRI is generally done preoperatively to assess the number, size, and location of myomas. Recently, cases done by robotic-assisted laparoscopic myomectomies have been increasing and criteria for robotic-assisted and traditional laparoscopic myomectomies should be identical. Comparing robotic-assisted laparoscopic myomectomies to traditional abdominal myomectomies, Advincula *et al.* found patients undergoing a robotic-assisted approach to have significantly less blood loss during surgery. In their study of 58 patients, the transfusion rate in patients undergoing open myomectomies was 6.9% compared to zero blood transfusions in the robotic-assisted laparoscopic cases. Postoperative complication rates were also less in the robotic arm of this study. Similar to the studies looking at robotic-assisted tubal anastomosis, the other advantage to robotic-assisted myomectomy was an overall decrease in hospital stay compared to the laparotomy group. Disadvantages noted were increased overall cost and operative time [32].

More recently, two retrospective reviews comparing traditional laparoscopic myomectomies to robotic-assisted laparoscopic myomectomies have been reported. In the study by Nezhat *et al.*, 15 robotic-assisted cases were compared to 35 traditional laparoscopic cases. This study found similar operative blood loss, complications, and hospital stay between the two groups. Hospital charges and operative time were again found to be significantly greater in the robotic-assisted group [33]. A slightly larger retrospective study by Bedient *et al.* also compared traditional and robotic-assisted laparoscopic myomectomies. After adjustment for uterine size, number of fibroids, and size of the largest fibroid, no significant difference in operative times was found between the two study arms. Intraoperative blood loss and surgical complications were also not significantly different after adjustment of data was performed. The authors noted that the robotic arm of the study had significantly fewer uterine incisions when compared to the traditional laparoscopic group, thought to be due to the improved instrument articulation in the robotic procedures. A potential benefit from this could be a decreased incidence of future uterine rupture [34].

One study looked at the impact of BMI on surgical outcomes in patients undergoing robotic-assisted laparoscopic myomectomies. This retrospective cohort study of 77 patients divided into five BMI groups found no intraoperative complications in the obese or morbidly obese patients. Additionally, they did not find any significant difference in procedure time, estimated blood loss, or hospital stay between the five BMI groups [35]. This study failed to find any evidence that increasing BMI worsened surgical outcomes in patients undergoing robotic-assisted laparoscopic myomectomies. Similar to the data on obese patients in the gynecological oncology literature, the minimally invasive technique of robotic-assisted myomectomies may give superior outcomes in the obese and morbidly obese patient population. Head to head trials of the surgical approaches should be done to verify this likely benefit.

There are other potential uses of robotic-assisted laparoscopic surgery in the field of reproductive medicine. For example, women needing to undergo pelvic radiation therapy are in danger of losing ovarian function. Ovarian transposition can be done to move the ovaries high above the field of radiation, giving protection to future ovarian function. The use of the da Vinci surgical system to perform this procedure has been described in the literature [36]. In the future, robotic-assisted laparoscopic surgery could be used for uterine transplant surgery. Currently experimental, this potentially complex procedure may benefit from the technical advantages of robotic-assisted surgery.

The future of robotic surgery

As technology continues to improve, advances will be made in the current robotic system that will further enhance its use. One limitation previously mentioned that exists in the robotic system is its lack of tactile feedback. This can be particularly frustrating when working with delicate tissue or fine suture material. With the current system, surgeons must adapt to visual cues alone. The ability to have tactile feedback would be a great improvement to the system and lessen the learning curve of robotic surgery.

Another limitation of the system is its large size. The three components of the robotic apparatus are very bulky and may not fit in some operating rooms. Ideally, future models will be decreased in size. One way to accomplish a size reduction of the system

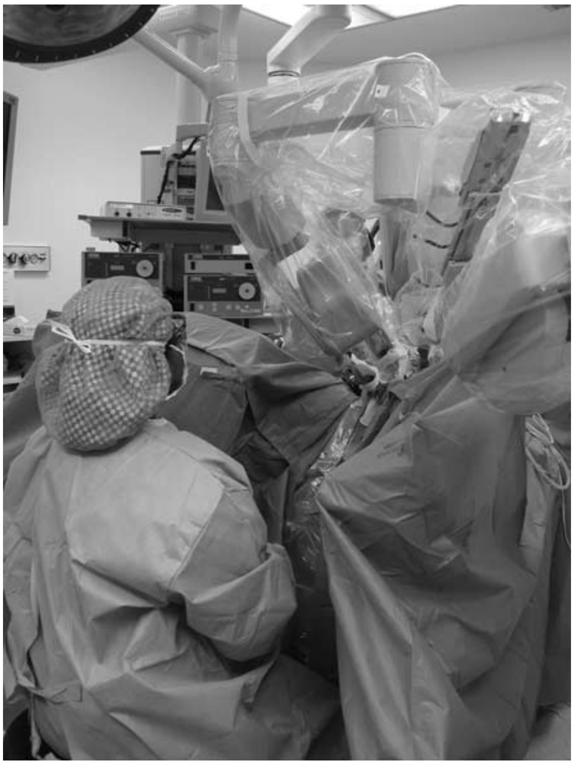

Figure 1.3. Side-docking of the patient side cart of the da Vinici Robotic System allowing improved assistant patient access for uterine manipulation.

would be to have rooms with the robotic system structurally incorporated. Permanent robotic operating suites with the arms attached to the ceiling of the operating room would help decrease some of the bulkiness. This will give better access to the patient for the assistant and may make docking easier and more efficient. Another way to achieve improved access to the patient is the incorporation of side-docking (see Figure 1.3). As previously mentioned, this new docking technique places the patient side cart next to the patient instead of between her legs. This gives easy access for uterine manipulation during procedures. Until robotically incorporated rooms are developed, side-docking can be used for improved patient access.

Other improvements of the robotic system include the addition of telesurgery technology and single-port systems. The Zeus robotic system was developed with telesurgery technology and has been used for this purpose [3]. The current da Vinci surgical system, however, is not available for telesurgery. The ability to perform surgery from a remote location can have a significant impact on patient care and access to care and should be incorporated into future robotic models. Single-port robotics is another area of robotics that is just being developed. Laparoendoscopic single-site surgery (LESS) is gaining in popularity for its minimally invasive nature and improved cosmetics (see Figure 1.4). The incorporation of robotics with LESS will facilitate

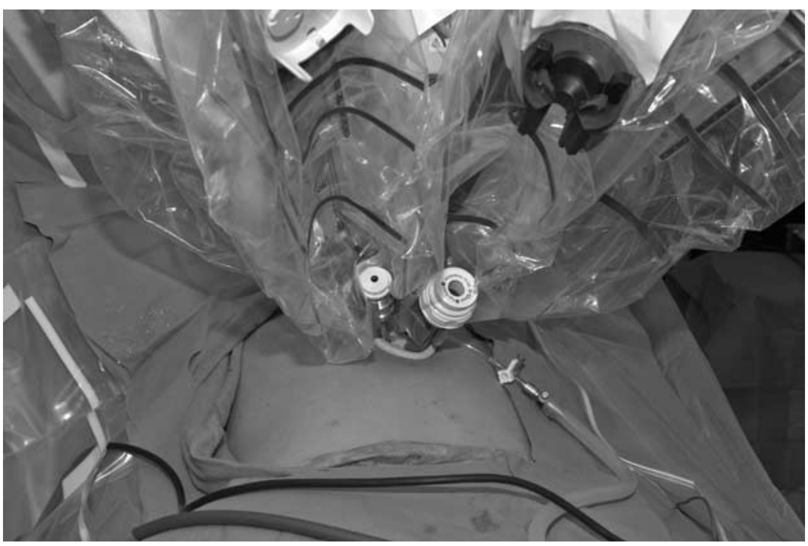

Figure 1.4. Robotic-assisted laparoendoscopic single-site surgery; only one trocar is required.

complex procedures. However, instrument arms will need to be improved upon to truly embrace this technique. Creating arms that are smaller and have greater intracorporal flexibility and articulation will be needed for single-port robotics.

Conclusion

Robotic surgery is emerging as a viable option for gynecological surgeons in general gynecology, urogynecology, oncology, and reproductive surgery. Feasibility has been demonstrated in all areas of gynecology. In each area the benefits of traditional laparoscopy translate well to robotically assisted laparoscopy. Decreased blood loss, shorter hospital stays, and faster recovery with lower morbidity are noted as compared with laparotomy. In many cases robotic surgery takes as long as laparoscopy. However, multiple studies demonstrate a rapid learning curve in which operative time steadily decreases, even becoming shorter than laparoscopy, some approaching laparotomy. Studies have demonstrated that few conversions to laparotomy were needed using the robotic technology. Furthermore, improved outcomes were noted on obese patients when robotic procedures were done instead of traditional laparoscopy. This finding alone opens many doors for obese patients previously considered poor candidates for minimally invasive surgery. More studies need to be done, particularly prospective randomized trials to demonstrate definitive benefit, or lack thereof, of the robotic technology as compared with laparoscopy and laparotomy. As institutions and surgeons become more familiar with the technology, hopefully these results will become available to develop the incorporation of robotic technology in gynecological surgery.

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