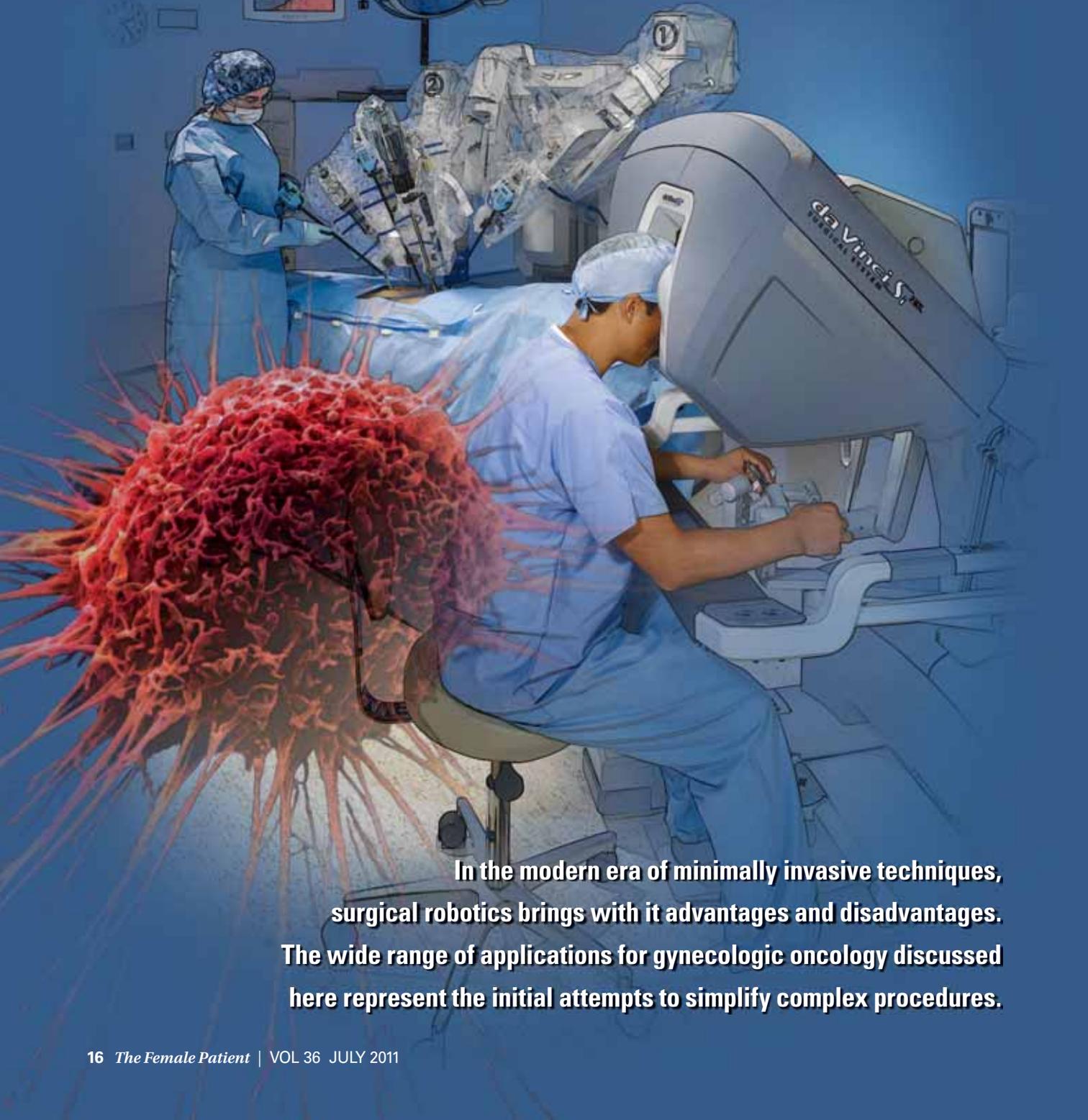


Robotic Surgery and Gynecologic Oncology: A Review of the Literature



In the modern era of minimally invasive techniques, surgical robotics brings with it advantages and disadvantages. The wide range of applications for gynecologic oncology discussed here represent the initial attempts to simplify complex procedures.

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Laparoscopic surgery has profoundly revolutionized the concept of minimally invasive surgery in the past 3 decades.¹ Studies have shown that laparoscopy has several advantages compared to laparotomy, including faster postoperative recuperation, shorter hospitalization course, cosmetic benefits, decreased blood loss, improved intraoperative visualization, and fewer complications.^{2,3} Despite these factors, several drawbacks exist with conventional laparoscopy. These include 2-dimensional views, counter-intuitive hand movements, a gradual learning curve, operator fatigue, and tremor amplification.^{4,5}

Computer-enhanced telesurgery, called robotic-assisted surgery, is the latest innovation in the minimally invasive surgery field. It attempts to overcome the disadvantages of conventional laparoscopy by offering improved dexterity, coordination, and visualization.⁶

The technology for today's robotic surgery evolved from the voice-activated robotic arm, AESOP® (Computer Motion, Santa Barbara, CA), to the current platform of surgical robots, the *da Vinci* Surgical System® (Intuitive Surgical, Sunnyvale, CA). The *da Vinci* was first approved by the FDA for general laparoscopic surgery in 2000. But it was not until 2005 that it was approved for gynecologic surgery, such as hysterectomy. It has since been incorporated into the gynecologic armamentarium with increasing frequency.

In gynecologic oncology, the robot has been increasingly used in a variety of applications, not only for radical hysterectomies in cervical cancer patients but also for pelvic and para-aortic lymphadenectomies and trachelectomies. In addition, it has a wide range of utility in the management of endometrial and ovarian cancer. The objective of this review is to critically

examine this novel technology and its current applications in malignant conditions.

SETUP

The setup of the *da Vinci* Surgical System is based on the principle of robotic telepresence: The main surgeon is seated at a master console away from the operating table, remotely guiding the movements of a patient-side robotic device with a camera arm and 2 or 3 operative arms. The latest version, the *da Vinci Si* model, also supports an assistant surgeon's console. The placement of the accessory ports in gynecologic oncology surgery varies with the type of procedure planned. Pelvic lymphadenectomy and para-aortic lymphadenectomy up to the inferior mesenteric artery have similar port placements (Figure 1). If lymphadenectomy above the inferior mesenteric artery is planned, trocar placement must be modified (Figure 2). (Thorough description of this technique is beyond the scope of this article but has been detailed elsewhere.⁷)

GYNECOLOGIC ONCOLOGY

Cervical Cancer

There is a rapidly growing body of literature for robotic procedures in treating cervical cancer, as there appears to be more of a need for complex and intricate procedures in the management of this malignancy. Robotic surgery specifically allows fine tissue dissection necessary in such procedures as ureterolysis and pelvic and para-aortic lymphadenectomy (Figure 3). Since Sert and Abeler reported the first case of a robotic-assisted laparoscopic radical hysterecto-

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FOCUSPOINT

Robotic-assisted surgery offers improved dexterity, coordination, and visualization.

my and pelvic lymphadenectomy in 2006, a number of articles have been published regarding robotic-assisted laparoscopic hysterectomy, pelvic and para-aortic lymphadenectomy, trachelectomy, parametrectomy, and ovarian transposition.^{8,9}

When comparing robotic-assisted radical hysterectomy and pelvic lymphadenec-

tomy with laparoscopic procedures, the results are either comparable or robotic procedures are found to be superior: Nezhat et al found operative time, estimated blood loss, and hospital stay to be equivalent.¹⁰ Sert and Abeler have shown that robotic procedures are technically feasible and offer similar histopathologic results, including number of lymph nodes, parametrial tissue, and vaginal cuff size.¹¹ They also found that robotic-assisted laparoscopy was associated with decreased blood loss and shorter hospital recovery when compared with laparoscopy.^{10,11}

When comparing robotic-assisted radical hysterectomy and pelvic lymphadenectomy to laparotomy, multiple studies have shown that robotic procedures are associated with a lower incidence of complications, decreased blood loss, higher lymph node retrieval, shorter hospital recovery, and equivalent outcomes.¹²⁻¹⁶

Robotic surgery utilized to treat cervical cancer is similar to laparoscopic surgery in the types of complications encountered. In a review of the literature, Cho and Nezhat noted that the most common complications occurring with robotic surgeries are lymphocysts/lymphoceles, pelvic infection, and vaginal cuff complications. In comparison, procedures performed via laparotomy involve wound and gastrointestinal complications.⁹

Endometrial Cancer

Minimally invasive techniques have been used more frequently in the management of uterine malignancy. The Gynecologic Oncology Group conducted a randomized prospective study comparing laparoscopy to laparotomy in the surgical treatment of uterine cancer.¹⁷ The investigators reported that laparoscopy is feasible and safe in terms of short-term outcomes and results in fewer complications and shorter hospital stay. They are continuing to collect data on long-term survival and recurrences in the 2 groups.

The majority of studies investigating robotic-assisted techniques and management of endometrial cancer have been case series, with more current studies evaluating the difference between laparoscopy and laparotomy.⁹ Two recent reviews of the literature arrived at the same conclusion:

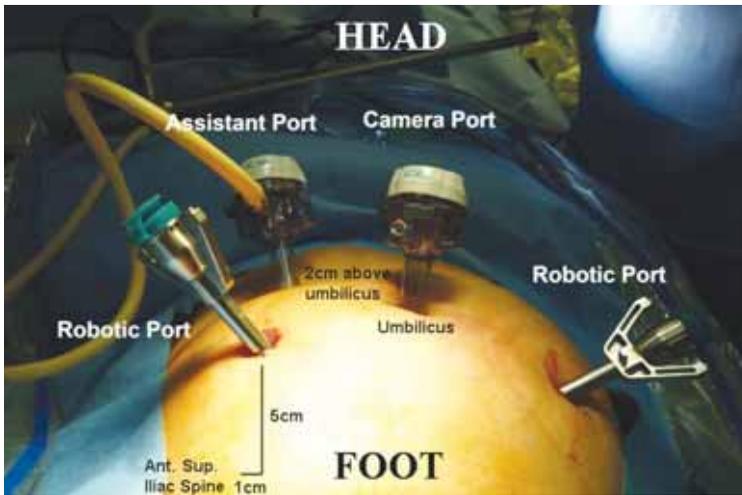


FIGURE 1. Trocar placement for pelvic lymphadenectomy and para-aortic lymphadenectomy up to the inferior mesenteric artery.

Image courtesy of Farr R. Nezhat, MD.

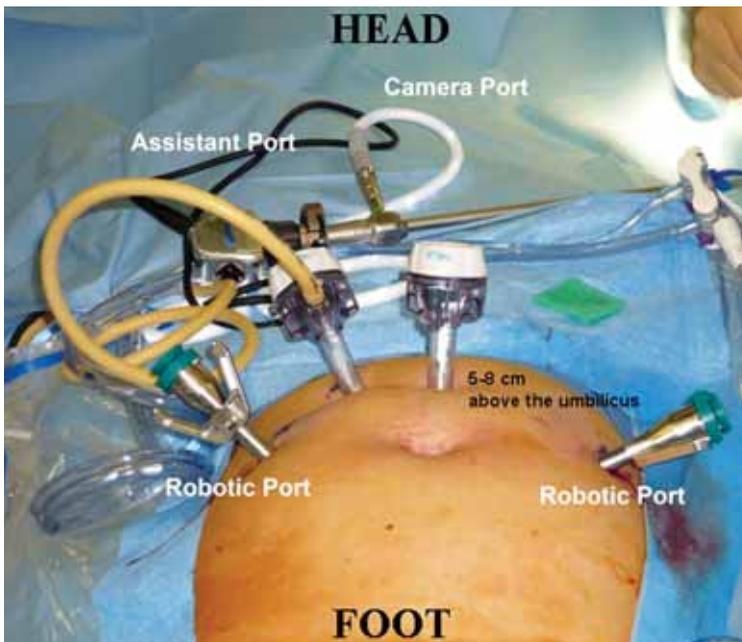


FIGURE 2. Trocar placement for para-aortic lymphadenectomy above the inferior mesenteric artery. The other trocar placements are adjusted using the camera port as the reference point. *Image courtesy of Farr R. Nezhat, MD.*

Robotic-assisted techniques when compared to laparoscopic treatment of endometrial cancer have similar perioperative clinical outcomes.^{9,18} In comparison to laparotomy, robotic and laparoscopic procedures had decreased blood loss and hospital stay but longer operative times. Lymph node retrieval was comparable among all 3 groups.

The robotic technique is especially useful in morbidly obese patients with endometrial cancer. Studies have shown that when robotic surgery in obese patients is compared to laparoscopy, robotic surgeries have shorter operative times, less blood loss, and increased lymph node retrieval. When compared to laparotomy, robotic surgeries have decreased blood loss, hospitalization time, complication rate, and wound problems (Figure 4).⁹

The most common complications noted with robotic surgery in treating endometrial cancer are conversion to laparotomy, vaginal cuff complications, and lymphocele/lymphocele complications. These are similar to the complications encountered with laparoscopic surgery. The unique complications affecting laparotomy procedures involve the incision and infectious issues.⁹

Ovarian Cancer

The data on the application of robotic technology for ovarian cancer staging are scant. There are only case reports or series in the literature documenting the experience with ovarian carcinoma and robotic-assisted laparoscopy.⁹ Six research groups included ovarian cancer in their case series analysis, each including up to 64 patients, with no subgroup analysis specifically for ovarian cancer patients. The average operative time and blood loss were not specifically reported for the subset of ovarian cancer patients.⁹

DISCUSSION

The review of the literature revealed multiple case reports and series but few randomized prospective studies. Most articles have been written within the past 3 years. Clearly, this is a burgeoning field,

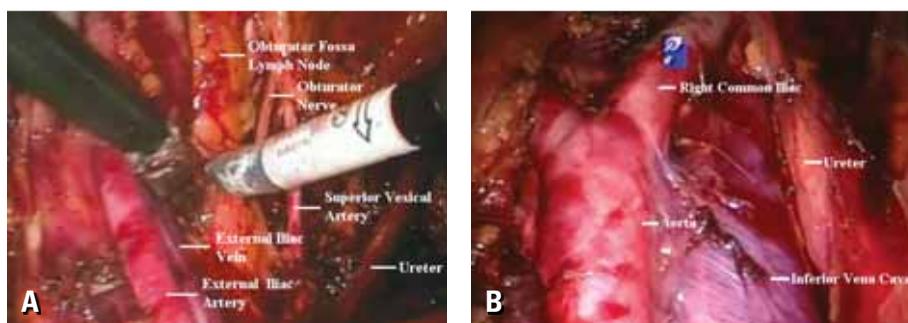


FIGURE 3. Robotic pelvic lymphadenectomy (A) and robotic para-aortic lymphadenectomy (B). *Images courtesy of Farr R. Nezhat, MD.*

and much research is still necessary to validate its position as an established tool for use in gynecologic oncology. Most studies support equivalent data between robotics and laparoscopy when outcomes such as operative time, estimated blood loss, and length of hospital stay are compared. This provides support to the potential role of robotics in gynecologic oncology as a useful adjunct to laparoscopy and a potential replacement in certain cases.

One of the main advantages of robotic-assisted laparoscopy over conventional laparoscopy is the improvement of surgeon ergonomics leading to decreased surgeon fatigue. Also, as with endometrial cancer, robotic-assisted laparoscopy has led to improved perioperative outcomes in the morbidly obese.

However, there are several drawbacks of the present *da Vinci* system that deserve mention. One of these disadvantages is the lack of tactile feedback. This accounts for approximately 11% of ruptured suture materials.¹⁹ The loss of haptics can be overcome with more experience and training. Seamon et al demonstrated that more conversions are expected during the initial transition to robotics; beyond the 65th percentile of procedures, no conversions were seen.²⁰

Secondly, the high cost of the system is often a deterrent. The substantial financial cost of robotics compared to the conventional laparoscopy causes practical barriers to its utilization. The average unit costs about \$2 million, with the instruments averaging



FIGURE 4. Well-healed trocar incision scars in a patient with BMI of 50 and endometrial cancer 2 months after robotic staging. *Image courtesy of Farr R. Nezhat, MD.*

\$2,000 per 10 uses. There are scant data regarding the financial impact of the robot, although Bell et al reported that laparotomy procedures were costlier than robotic procedures due to the increased length of hospital stay.^{19,21} As robotic technology becomes more familiar and prevalent, the cost of supplies and equipment may decrease.

Robotics presents a new paradigm in the field of minimally invasive surgery, but like any novel technology, it has its advantages and limitations. The initial experiences with case series and cohort studies appear promising, but with the lack of randomized prospective studies, there continues to be the need for further research in this field. In terms of gynecologic oncology procedures, long-term outcome studies comparing robotic, laparoscopic, and laparotomy approaches also need to be evaluated.

Robotic-assisted laparoscopy has made minimally invasive procedures possible in certain patients, such as the morbidly obese. The advantages it provides in cases that require fine dissection and decreasing operative fatigue in extended cases have had a significant impact on its utility. However, the cost and complexity of the device and setup must be taken into account in selecting operative cases.

In the modern era of minimally invasive techniques, current developments in surgical robotics represent only the initial attempts to simplify complex laparoscopic procedures. Much research and development are still needed to fully appreciate the potential of robotics in the operating arena and to adequately train the surgeons of the future.

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FOCUS POINT

More research and development are needed to fully appreciate the potential of robotics.