Robotic-assisted surgery in gynecologic oncology

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The quest for improved patient outcomes has been a driving force for adoption of novel surgical innovations across surgical subspecialties. Gynecologic oncology is one such surgical discipline in which minimally invasive surgery has had a robust and evolving role in defining standards of care. Robotic-assisted surgery has developed during the past two decades as a more technologically advanced form of minimally invasive surgery in an effort to mitigate the limitations of conventional laparoscopy and improved patient outcomes. Robotically assisted technology offers potential advantages that include improved three-dimensional stereoscopic vision, wristed instruments that improve surgeon dexterity, and tremor canceling software that improves surgical precision. These technological advances may allow the gynecologic oncology surgeon to perform increasingly radical oncologic surgeries in complex patients. However, the platform is not without limitations, including high cost, lack of haptic feedback, and the requirement for additional training to achieve competence. This review describes the role of robotic-assisted surgery in the management of endometrial, cervical, and ovarian cancer, with an emphasis on comparison with laparotomy and conventional laparoscopy. The literature on novel robotic innovations, special patient populations, cost effectiveness, and fellowship training is also appraised critically in this regard. (Fertil Steril® 2014;102:922–32. ©2014 by American Society for Reproductive Medicine.)

Key Words: Robotic surgery, cervical cancer, endometrial cancer, ovarian cancer, single site, sentinel lymph node

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Minimally invasive surgery is the standard of care for the treatment of a variety of benign (1–4) and malignant (5–7) gynecologic conditions. Approximately half of the estimated 500,000 hysterectomies performed annually in the United States are carried out with vaginal, laparoscopic, or robotic-assisted surgical approaches. Level I studies demonstrate the benefits of minimally invasive surgery compared with laparotomy, including improved perioperative outcomes, shorter hospital stays, improved quality of life, and a faster return to daily functions and the workforce. In addition, in gynecologic oncology patients, minimally invasive surgery appears oncologically safe when performed in women with apparent early stage disease or in women who have isolated tumor recurrences (5–8).

The da Vinci surgical system (Intuitive Surgical) was initially approved by the Food and Drug Administration in 2005 for use in gynecologic surgery. Since then there has been a growing body of published reports evaluating the utility of robotic-assisted surgery in gynecologic oncology. Accordingly, robotic-assisted surgical approaches have been used increasingly in the setting of risk-reducing uterine and adnexal surgery, and for the treatment of endometrial cancer (5–7, 9, 10), cervical cancer (9, 11–16), adnexal masses, and ovarian cancer (17–21). Robotic-assisted surgical technology addresses several of the limitations associated with conventional laparoscopy, including lack of depth perception, two-dimensional optics, camera instability, limited range of motion, and steep learning curves.

Robotically assisted technology offers advantages that include improved three-dimensional stereoscopic vision, wristed instruments that improve dexterity, and tremor canceling software that improves surgical precision. However, the platform is not without limitations, including high cost, lack of haptic feedback, and the requirement for additional training to achieve competence. Furthermore, and of particular interest to the gynecologic oncologist, the platform is not intended for simultaneous multiple quadrant surgery. Despite these limitations, the technology has been widely adopted and has achieved considerable penetrance within the US gynecologic oncology surgeon community. It

Received June 1, 2014; revised and accepted August 12, 2014.
A.K.S. has nothing to disclose. A.N.F. has nothing to disclose.
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Fertility and Sterility® Vol. 102, No. 4, October 2014 0015-0282/$36.00

http://dx.doi.org/10.1016/j.fertnstert.2014.08.020

remains unclear in comparison studies, however, whether robotic-assisted surgery is truly superior to conventional laparoscopy for the treatment of oncologic conditions. Randomized controlled trials comparing these surgical approaches are lacking. The purpose of this review is to assess the current state of robotic-assisted surgery in gynecologic oncology and to conduct a critical appraisal of the published literature on the use of robotic-assisted surgery in the treatment of gynecologic malignancies. This was achieved by performing a PubMed search to identify published English language manuscripts that included the key words robotic, robotic surgery and ovarian cancer, cervical cancer, and endometrial cancer. Relevant articles were then analyzed in detail for inclusion in this review.

THE GYNECOLOGIC ONCOLOGY PATIENT

The diversity in the characteristics of patients afflicted with gynecologic malignancies is a function of the different etiologic factors associated with these diseases. Because of these differences, various surgical approaches, often by robotic-assisted surgery or other minimally invasive techniques, are used. Women diagnosed with cervical cancer are often young, have been exposed to the human papilloma virus, and require radical or fertility sparing surgery with curative intent. On the other hand, ovarian and endometrial cancer are diseases of the elderly and obese (22), and special consideration for surgical intervention with regard to recovery and complication rates is warranted. Age should never be considered as an independent, isolated contraindication to surgery, as performance status and the presence of comorbid medical conditions are more predictive of surgical complication rates (23–25). Older patients, however, are more likely to have associated comorbidities such as hypertension, cardiac, and pulmonary disease (26). Furthermore, obesity and diabetes are often present in patients with gynecologic cancer, and this further compounds the perioperative risk, including but not limited to, deep vein thrombosis and surgical site infections (27, 28).

As such, this patient population may especially benefit from minimally invasive surgical interventions. In addition, robotic-assisted surgery, in particular, may offer advantages versus other minimally invasive modalities in the morbidly obese. The surgically complex patient will be explored in the following sections.

PENETRANCE OF ROBOTIC-ASSISTED SURGERY IN GYNECOLOGIC ONCOLOGY

At present, more than 2,100 robotics have been installed in the United States (29). In fact, only 4 years after its clearance for gynecologic applications, 24% of gynecologist oncologists reported using robotic-assisted surgery, with 66% indicating that they planned to increase their use of the procedure in the next year (30). Similar to physicians who adopted laparoscopy early on in its development, gynecologic oncologists who completed their training less than 5 years before the present study were more likely to adopt robotic-assisted surgery than those who completed fellowship more than 15 years ago. Another survey, published in 2010, noted that 95% of gynecologic oncology fellows have a robotic platform at their institutions, and 95% were trained to use it (31). In this same study, 74% of fellows were trained to perform robotic-assisted lymph node dissection and 44% performed radical hysterectomies (31). These and other studies contributed to the Society of Gynecologic Oncology's robotic task force position statement that acknowledged that robotic-assisted surgery has indeed "markedly changed" the practice patterns in the US gynecologic oncologist community (32).

ROBOTIC-ASSISTED SURGERY IN CERVICAL CANCER

Background

Despite recent advances in Papanicolaou smear (Pap) screening and human papilloma virus vaccination, cervical carcinoma remains a significant cause of morbidity and mortality worldwide. In the United States, 12,000 cases of cervical carcinoma are diagnosed annually and 4,000 deaths are attributed to this preventable disease (22). Cervical carcinoma is the second most common indication for the use of robotic-assisted surgery (32). Abdominal radical hysterectomy (ARH) has been the traditional standard of care for patients with early disease (FIGO stage 1A2-IIA), with 5-year overall survival rates of 62%–90% (33). The intricacies of radical hysterectomy, which include a sophisticated dissection of the parametria, unroofing of the ureter from the ureteric canal within the cardinal ligament, and an en block resection of the uterus, cervix, parametria, and uterosacral ligaments, make it an ideal surgery for adoption into the robotic platform, especially as only a small number of surgeons adopted the laparoscopic technique for this complex procedure.

Radical Hysterectomy for Cervical Cancer

Multiple studies have assessed the feasibility and safety of robotic-assisted radical hysterectomy (RRH) (Table 1). In 2008, Boggess et al. (34) published a case series of 51 consecutive RRHs performed on patients with FIGO stage IA1-IIA cervical cancer diagnosed between June 2005 and November 2007, and compared them with 49 consecutive patients undergoing ARH who were matched for cancer type and stage. Significantly less blood loss (96 vs. 411 mL), less operative time (210 vs. 247 minutes), shorter hospital stay (1 vs. 3.1 days), and a significantly increased mean number of lymph nodes retrieved (33.8 vs. 23.3) was noted in the robotic-assisted cohort. Postoperative complications were less in the RRH group, but this was not statistically significant. The investigators concluded that RRH may have more favorable outcomes when compared with ARH and that the traditional laparoscopic radical hysterectomy experience was not required to use the robotic-assisted approach, as the surgeons did not have extensive experience in total laparoscopic radical hysterectomy (TLRH).

These data were later corroborated by Magrina et al. (8), who compared the three approaches (RRH, TLRH, and ARH) to radical hysterectomy. The robotic-assisted approach was associated with less mean blood loss, operative time, and duration of hospital stay than both the open and traditional laparoscopic techniques. Another study (10) retrospectively