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Review Article

Robotic Surgery for Gynecologic Cancer: Optimism or Controversy in Surgical Oncology?

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Abstract: Robotic Surgery has made possible to remove cancerous organs and tissues in gynecologic cancer patients with less invasive methods. Gynecologist have observed that these minimally invasive surgeries often result in fewer complications and a faster recovery time. As robotic technology continues to develop, the potential advantages of robotic surgery in gynecologic oncology are becoming increasingly evident. Robotic Surgery offers greater precision and control during complex procedures, which can lead to improved patient outcomes and fewer complications. Robotic surgery can often outcome in smaller hospital halts and a rapid return to normal activities. Consequently, more and more GOs are adopting Robotic Surgery to provide their patients with the most advanced and effective treatment options available. Robotic Surgery is now a viable option compared to traditional open surgery. Since its extensive use, negligibly aggressive surgery has become a suitable choice not only for those with severe obesity, but also for women with gynecologic cancers, where traditional open surgery is often associated with significant complications. This review investigates the rationale behind Robotic Surgery, evaluates early results, analyzes its cost-effectiveness and implications for surgical training, and explores innovative applications of robotic-surgical procedure in the treatment of gynecologic cancer.

Keywords: Robotic, Robotic Surgery, Cancer, Radiation, Chemotherapy, Gynecologic and oncologists

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1. INTRODUCTION

Treatment for gynecologic cancer often includes surgery, followed by chemotherapy, radiation or amalgamation of both. Gynecologic oncologists (GOs) must consider the methodological features of surgery in relation to the patient's goals, the extent of cancer removal, the expected recovery time, and how these affects future cancer treatments[1]. Minimally invasive techniques, like laparoscopy and Robotic Surgery (RS), have been developed to address these factors[2]. GOs discovered that laparoscopic surgery resulted in fewer surgical complications and faster recovery. This led to more complex procedures, such as radical hysterectomies for gynecologic cancers, being performed laparoscopically with excellent outcomes. RS has further enhanced precision and control, allowing for more intricate procedures with less damage to surrounding tissues. These advancements in minimally invasive surgery have revolutionized gynecologic oncology, leading to improved patient outcomes and quality of life. Patients undergoing laparoscopic or robotic procedures typically experience smaller hospital stays, less pain, and a less day return to standard activities[3]. As technology continues to advance, the future of gynecologic oncology surgery is fast growing, with even more complex procedures likely to be performed using minimally invasive techniques. Robotic treatment center has prolonged the number of women who are eligible for minimally invasive procedures, including those who are severely obese, in poor health, or have many other health conditions[4]. The initial achievements of RS in treating endometrial cancers have led endometrial oncologists to consider this approach repeatedly. This review focuses on the use of RS in the treatment of gynecologic cancers, such as cervical, endometrial, and ovarian cancers[5]. The precision and control of RS have made it possible to perform more complex procedures with a lower risk of complications[6]. As equipment continues to advance, the use of robotics in gynecologic oncology is predictable to become even more widespread. Overall, the benefits of RS in treating endometrial cancers are becoming increasingly clear, offering patients a safer and more effective treatment option.

2. METHODOLOGICAL CONSIDERATIONS OF RS IN THE MANAGEMENT OF GYNECOLOGIC CANCER

RS differs significantly from traditional laparoscopy in several key aspects. Laparoscopy uses a 2-dimensional camera that sends images to screens near the specialist in the operating room. Surgery is accomplished through small incisions of 5 to 12 millimeters, where a camera and stiff tools are inserted into the abdomen and manipulated directly by the surgeon[7]. Conventional laparoscopy can be limited by difficulties in manipulating instruments and the limitations of two-dimensional images, which can make complex procedures in radical pelvic surgery more challenging[8]. Although skilled laparoscopic surgeons can perform fundamental hysterectomy whether or not lymphadenectomy using laparoscopic instruments, the specialized assistances and unusualness with 2-dimensional images required for laparoscopy have led to its limited adoption by GOs. The number of people who can benefit from minimally invasive treatment for gynecologic cancer is limited. The overview of robotics has addressed several challenges faced by inexperienced laparoscopic surgeons, and the improved ergonomics of the robotic platform resolves these challenges. By means of a robotic platform for surgical procedures permits the lead specialist to manipulate surgical tools (up to 3 instrument arms and a camera) without directly touching them. The surgical instruments have a wider series of motion compared to traditional laparoscopic tools, allowing for "wristed action" rotation and motion scaling[9]. Superior optics provide a 3-dimensional view of the operating area. The technological aspects of RS make it easier for surgeons to learn new surgical skills and adapt their existing skills to the RS framework. The two most common robotic platforms are the ZEUS and the da Vinci systems[10]. Both robotic devices allow the gynecologic oncologist to control the surgery from a support away from the patient. Even though the surgeon is not at the bedside, the 3-dimensional images, the ability to rotate the instruments like a wrist, the elimination of hand tremors, and the ability to scale movements have increased the interest of GOs in performing cancer procedures using a slightly aggressive robotic device.

3. RS FOR CERVICAL CARCINOMA

Many GOs question whether RS can completely replace traditional open surgery for all gynecologic cancer patients. Beyond clinical trials, it's important to consider the goals of surgery, patient recovery, and risk factors for cancer recurrence. Data from cervical cancer patients show that RS effectively assesses tumor size, grade, spread, lymph node involvement, and clear resection margins, while minimizing surgical injuries[11]. GOs performing robotic radical hysterectomy for cervical cancer must ensure their surgeries provide essential information for deciding on additional radiation or chemotherapy. Early-stage cervical cancer patients treated with RS have shown promising results. Blood loss is minimal after robotic radical hysterectomy for cervical cancer. Operating times are longer than with traditional methods, but they improve with experience. Robotic and laparoscopic surgeries are related with fewer complications like lymphocysts, lymphoceles, infections, and ileus. This has led to extensive use of RS in early-stage cervical cancer. As cervical cancer screening improves early detection of organ-confined disease, RS is probable to become more common in these cases. However, there's limited experience with RS for larger cervical cancers. Randomized trials comparing RS to laparoscopy or traditional open surgery are needed. While early results for early-stage cervical cancer are promising, caution is advised due to insufficient data on port and surgical site recurrence. Four studies evaluated the outcomes of robotic assisted radical hysterectomy for cervical cancer. The da Vinci robotic platform was used in three studies[12-14], while the Zeus/da Vinci platform was used in one study[15]. Across the studies, the average operative time ranged from 207 to 264 minutes, blood loss from 82 to 355 mL, and lymph node count from 20 to 34. Comprehensive surgical staging was achieved in 91% to 100% of cases. Complications included pneumothorax, pleural effusion, cystotomy, lymphocyst, lymphedema, and self-catheterization of the bladder. Port site degeneration occurred in 0% to 2.9% of cases. Overall, RS for cervical cancer appears to be a harmless and active option, with promising outcomes and low complication rates.

4. RS FOR OVARIAN CANCER (OCR)

Ovarian cancer surgery has traditionally included extensive laparotomies for debulking and staging, including pelvic and para-aortic lymph node dissection as well as omentectomy[16]. Given that it is fundamentally a disease of the peritoneum and that complete debulking—defined as the absence of any macroscopically visible residual tumor—is crucial for a

favorable prognosis, there has been an increasing focus on the total excision of the peritoneum and diaphragm. Holloway and coauthors have reported the first robot-assisted resection of the diaphragm, a procedure challenging to do by open surgery[17]. A case-control study has been conducted comparing robot-assisted and traditional laparoscopy with laparotomy for the debulking of ovarian cancer, despite the perception that surgical removal of large tumors in ovarian cancer patients is only viable by laparotomy. Despite the comparison of just 25 instances of robotic surgery with 25 cases managed by laparoscopy or laparotomy, the findings indicated a preference for the laparoscopic method when only one supplementary excision was conducted next to the primary tumor[18]. In all instances involving more extensive surgery, laparotomy proved to be better. As secondary surgery for recurring illness gains acceptance, it is important to acknowledge that in certain circumstances of restricted and localized disease, robot-assisted laparoscopic surgery and even exenteration are viable options. Effective treatment for epithelial ovarian cancer requires extensive surgery to remove as much of the tumor as possible. Recurrence and survival are linked to the extent of surgical removal. Microscopic residual disease followed by chemotherapy offers the best survival rates. OCr is often identified at a cutting-edge stage, requiring major surgery[19]. Since the 1990s, minimally invasive surgery has been explored for optimal tumor removal. The effectiveness of RS in this area is uncertain. While RS offers improved ergonomics, its limitations, such as the powerlessness to operate instantaneously in the pelvis and abdomen, remain substantial. RS for OCr is largely unproven. Limited experience shows low blood loss and complications like intestinal damage and wound dehiscence. Port site relapses are not consistently reported in early studies. One study compared RS to traditional methods for ovarian cancer staging[20]. It found that robotic or laparoscopic surgery is a viable option for removing primary tumors in selected patients. However, these patients were carefully chosen, and the results may not apply to all ovarian cancer patients. For severe disease requiring multiple complex surgeries, open surgery is often preferred. Clinical studies suggest that injecting chemotherapy directly into the abdomen should be further explored for ovarian cancer with intra-abdominal spread. While RS may reduce complications, recovery time, and the wait for chemotherapy, it has a potential drawback: tumor cells may contaminate the port sites used for robotic instruments. This could potentially affect the effectiveness of chemotherapy[21]. More research is needed before recommending RS for ovarian cancer. Two studies evaluated the outcomes of robotic-assisted surgery for ovarian cancer. The da Vinci robotic platform was used in both studies[22]. In a study 22, one patient with stage IV disease underwent liver and diaphragm excision. The average operative time was 137 minutes, blood loss was 100 mL, and complete debulk to less than 2 cm was achieved. In study 23, 25 patients with stages I-IV disease underwent debulk hysterectomy[23]. The average operative time was 315 minutes, blood loss was 164 mL, and complete debulk was achieved in 84% of cases. Complications included customizes, aortic bleeding, vaginal dehiscence, and ileus. No port site relapses were reported in either study. Overall, RS for ovarian cancer appears to be a safe and effective option, even in complex cases involving extensive surgery.

5. RS FOR ENDOMETRIAL CANCER

In endometrial cancer, randomized controlled data indicates that laparoscopic comprehensive surgical staging is viable, exhibiting acceptable conversion rates and comparable intraoperative complication rates, while resulting in fewer postoperative difficulties than the laparotomy method[24]. Recent longitudinal data from the LAP2 research indicated that laparoscopic staging was linked to a 3-year recurrence rate of 11.4%, in contrast to 10.2% for laparotomy, and did not negatively impact overall survival or recurrence patterns[25]. Robotic-assisted laparoscopy addresses the technical difficulties associated with traditional laparoscopy and has been swiftly embraced by gynecologic oncologists for thorough surgical staging of endometrial cancer, regardless of their prior laparoscopic experience, due to its superior ease of mastery and enhanced efficiency in complex cases, such as those involving morbid obesity.1.17 Lim and co-authors reported that the learning curve for robotic endometrial cancer staging was more rapid than that of laparoscopy, after analyzing operative times in chronological order for their first 122 patients of both techniques[26].

6. RS IN ANTICIPATION OF RADIATION THERAPY

Surgery for gynecologic cancers often involves removing pelvic organs, which can prevent future pregnancies. However, in some cases, such as teenage female lymphoma or cervical cancer, fertility-preserving surgery and targeted radiation therapy may be measured[27]. To protect the ovaries from radiation, they can be moved to a different location using laparoscopy or robotics. RS can be beneficial in treating cervical cancer, as demonstrated in many cases. Moving the ovaries to the midline or lateral iliac wings, liable on the radiation plan, can reduce radiation exposure to the ovaries to between 4% and 8% of the pelvic radiation dose[28, 29]. After the procedure, the new position of the ovaries should be marked with surgical clips that are visible on radiation therapy images. While optimal surgical removal of gynecologic cancers may limit the use of RS, the potential of RS to preserve fertility should not be unnoticed when radiation treatment is considered.

7. TRAINING OF SURGEONS IN RS

Hysterectomy and gynecologic organ surgery are some of the most common procedures performed on women, along with cesarean birth. Surveys show that surgeons have improved their use of robotic-assisted surgeries[30]. This trend suggests that RS training should be a core part of surgical residency. An operative platform for teaching RS may include didactic symposia and clinical dry laboratory experience. A robotic platform offers improved positioning and vision for surgeon training, except for the most skilled laparoscopic surgeons. Surgical time decreases with experience. It's been suggested that a surgeon and team need 12 cases to develop a coordinated approach for efficient RS; operating room times decreased from an average of 410 minutes to 337 minutes in one series[31]. A specialized hospital-based surgical robotics team can help minimize operating time, overall room time, and resource use. Training surgical residents and novice surgeons in robotic techniques may initially increase operating and overall room times; however, mastering this essential skill is crucial for their future practice. Experienced surgeons should be patient during this training. Additional metrics for robotic skill proficiency includes the complexity of surgical cases performed using robotics and the conversion rates from robotic procedures to laparotomy. The first training for pelvic

RS may involve performing a hysterectomy, which should be mastered using abdominal, vaginal, and laparoscopic techniques. Incorporating a robotic-assisted technique into the learning surgeon's skill set seems to be a logical first step. A study found that novice surgeons in RS experienced a significant learning curve for robotic-assisted vaginal suturing. Translation rates from robotics to laparotomy vary between 3.5% and 13%, attributed to various factors[32]. Legal actions have been initiated against surgeons for inadequate training or credentialing and for failing to obtain informed consent for RS. Physicians who did not receive RS training during their residency must recognize that counseling a woman about RS requires a thorough understanding of the procedure's inherent risks. Patients should be informed about a specialist's expertise and presentation in RS, as well as the inherent challenges associated with the procedure[33]. This doesn't mean that RS is inherently dangerous; rather, it emphasizes the physician's need to inform the woman about the predicted risks and their mitigation during robotic-assisted surgery. It's essential to address legal issues stemming from inadequate training, certification, and informed consent. All robotics in gynecology are shown in figure 1.

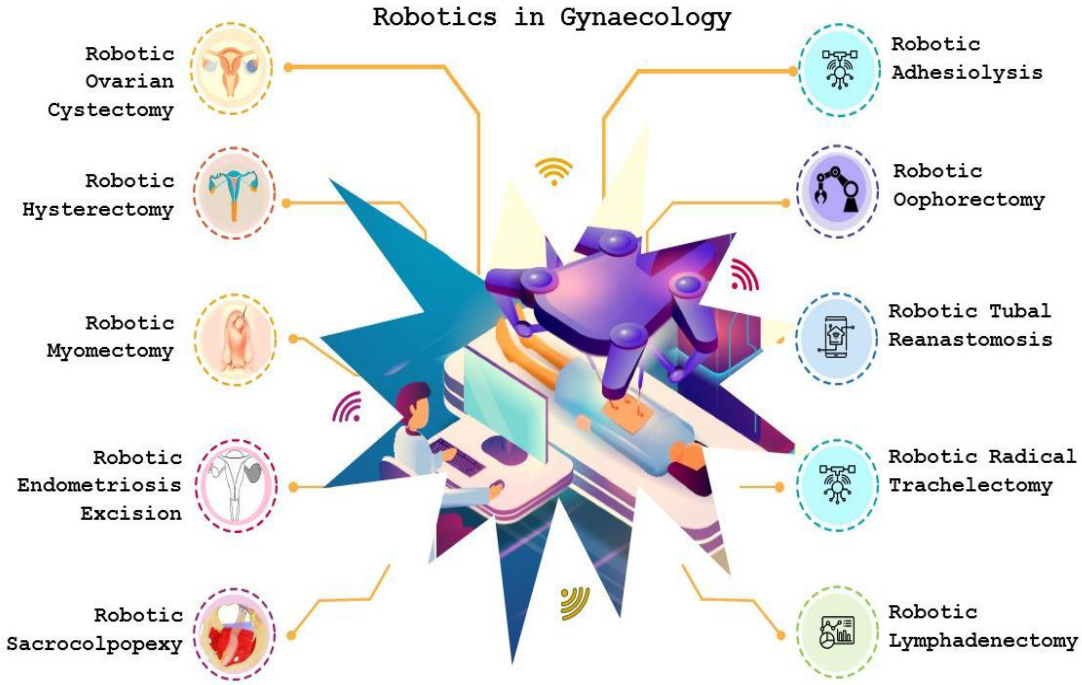

Fig 1: Robotics in Gynecology

8. CRITICAL ISSUES

Certain concerns surrounding traditional and specifically robot-assisted laparoscopic treatment of malignant diseases have to be resolved. Some of these issues are connected to technique, while others may stem from particular characteristics of endoscopic surgery. Surgical trauma affects the immune system, resulting in substantial alterations in host immunity. In patients undergoing treatment for colorectal cancer, cell-mediated immunity was more effectively conserved during laparoscopic resection compared to standard resection[34]. Furthermore, more aggressive tumor proliferation has been seen after open surgical procedures compared to endoscopic experimental techniques. Concerns have been expressed that laparoscopic surgery may lead to increased recurrence rates and a distinct recurrence pattern[35]. In a comparison of patients treated partially with laparoscopic lymphadenectomy, at a period when radical hysterectomies were not performed laparoscopically, with those treated exclusively by laparotomy, no difference in disease-free survival was seen. Locoregional recurrence was more prevalent in the open surgery cohort, although the distant recurrence incidence was comparable across both cohorts[36]. Although robot-assisted surgery enables surgeons to investigate and excise regions that are difficult to access with traditional laparoscopy or laparotomy, apprehension persists over the efficacy of a less invasive technique in thoroughly eliminating the tumor. In cases with significant illness, this may well be applicable. In cases with small-volume illness located in hard-to-reach regions, robot-assisted laparoscopic excision may be the most successful method due to its benefit of customizing the amount of resection[37]. Legal concerns, such as the accountability of proctors or a surgeon steering an operation away from the patient, are seldom discussed[38]. Under current US legislation, proctors are not liable for the activities of the surgeons they oversee. Nonetheless, the deployment of somewhat autonomous robotic systems may provide legal and ethical challenges that will need our increased focus.

9. CONCLUSION

While initial results for negligibly invasive RS in women with GCs are promising, queries remain about its surgical effectiveness. RS has shown encouraging results with compact complications in small studies. More research is needed to understand the technical aspects of RS before it's widely used in treating gynecologic cancers. It's important to explore alternative surgical methods with precision, but it's unclear if RS can provide the same therapeutic benefits as open surgery. Economic comparisons between RS and other surgical methods are ongoing. Both eagerness and caution are needed when understanding existing RS findings for gynecologic cancers. Ultimately, randomized data will be essential for

accurately evaluating the oncological outcomes of RS in treating gynecologic cancers.

10. AUTHORS CONTRIBUTION STATEMENT

Dr. Anand Mohan Jha, Dr. Anil Kumar conceptualized the manuscript and gathered the data. Dr. Rashmi Hosamani, Dr. John Abraham and Dr. Isha Madne analyzed the data and provided the necessary information regarding the research design. B Aishwarya took the lead in writing the manuscript. Murtaza Abbas Makasarwala provided critical feedback, reviewed, and helped in the final corrections of the manuscript.

11. CONFLICT OF INTEREST

Conflict of interest declared none.

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