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Minimally Invasive Surgery in Gynecology: Underutilized?

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Abstract Minimally invasive gynecologic surgery encompasses vaginal, laparoscopic, and robotic-assisted surgery. In this review, we highlight the current use of laparoscopic and robotic-assisted surgery in benign and oncologic gynecology and explore whether utilization is optimal. Given the many benefits associated with minimally invasive surgery, including fewer perioperative complications, less blood loss, and faster recovery times, it is critical to offer as many gynecologic surgery patients as possible a minimally invasive approach.

Keywords Laparoscopic gynecologic surgery · Robotic gynecologic surgery · Laparoendoscopic single-site surgery · Minimally invasive gynecologic surgery · Utilization of minimally invasive surgery

Introduction

The concept of minimally invasive surgery with the use of a laparoscope was first introduced in the 1800s by Dr. Desormeaux from Frankfurt, Germany, who was the first physician to design an endoscope to successfully explore the urethra and the bladder [1]. Exploration of the peritoneal cavity, or "celioscopy," was first performed by German-born surgeon Dr. George Kelling in 1901 [1, 2]. However, Dr. Hans Christian Jakobeous was the first to publish on the use of the laparoscope to explore the peritoneal cavity. In 1912, he published his findings on 109 laparoscopic explorations performed on 69 patients [1, 3, 4]. Laparoscopy became an important part of gynecologic surgery between the 1960s and 1970s. During that time, Dr. Kurt Semm from Germany perfected the automatic insufflation device and introduced thermocoagulation to laparoscopy. He also created several instruments including the suction irrigator to be used during laparoscopic surgery and the hooked scissors. It was during this time that laparoscopic lysis of adhesions, tumor biopsy, and staging was gaining popularity [1, 3–5].

The use of minimally invasive surgery in the fields of both gynecology and gynecologic oncology has been studied extensively over the past several years. It is well established that minimally invasive surgery leads to decreased length of hospital stay, improved patient outcomes, and increased patient satisfaction compared to open abdominal gynecologic surgery. However, despite level I data demonstrating improved clinical outcomes for most patients, it remains to be determined if minimally invasive surgery is being utilized as often as surgically indicated. This commentary and review article emphasizes the benefits of minimally invasive gynecology surgery and explores current utilization in the USA as well as barriers to widespread adoption of this surgical approach.

Factors Influencing the Use of Minimally Invasive Surgery in Gynecology

In reality, there appear to be considerable disparities in gynecologic surgical care nationwide. According to Cooper et al., laparoscopic hysterectomies are most likely to be performed in large, urban teaching hospitals [6•]. Rural hospitals are less likely to perform laparoscopic hysterectomies. Cohen et al. identified that a laparoscopic hysterectomy was most likely

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to be performed in women over the age of 50 and in the Western USA, in a high-income area [7]. Also, the diagnosis of a menstrual disorder or prolapse was most likely to be considered appropriate for laparoscopic approach, compared with surgery for uterine fibroids or malignancy. Other factors that were associated with the use of an abdominal approach included fibroid disease, a minority patient population, Medicare or Medicaid coverage, and the likelihood for the need for concomitant adnexal surgery. Obesity has historically been considered a contraindication to laparoscopy; however, Scheib et al. described the successful use of laparoscopy in this patient population. In the contemporary setting, obesity is no longer a factor that should deter a surgeon from considering minimally invasive surgery, as this approach decreases the incidence of wound infections, length of hospital stays, and recovery time in this population [8].

In the setting of robotic-assisted surgery, more than 2100 robotics platforms have been installed in the USA [8]. In fact, only 4 years after its clearance for gynecologic applications, 24 % of gynecologic oncologists reported using robotic-assisted surgery, with 66 % indicating that they planned to increase their use of the procedure in the next year [9]. Gynecologic oncologists who finished their training recently are more likely to use robotic-assisted surgery than those further removed from their training. A 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. In this same study, 74 % of fellows were trained to perform robotic-assisted lymph node dissection and 44 % performed radical hysterectomies [10, 11]. Barriers preventing the use of robotic surgery include availability of equipment and training; however, more recently, these barriers have been abolished and a rise in the use of robotic surgery is evident.

The Current Use of Laparoscopy in Gynecologic Surgery

Hysterectomy is one of the most common non-obstetrical procedures performed in the USA. Approximately 500,000 cases are performed annually. It is widely known that these benefits include shorter hospital stays, shorter recuperation times, faster return to regular activity, and a smaller drop in hemoglobin [12•]. There are also fewer wound and abdominal wall infections using the laparoscopic approach.

Since the 1990s, the use laparoscopy in the field of gynecology has been steadily rising. In 2002, Farquhar et al. performed an analysis of the Nationwide Inpatient Sample assessing the rates of hysterectomy between the years 1990 and 1997. At that time, rates of hysterectomy varied between 5.5 and 5.6 in 1000 women undergoing hysterectomy. By 1997 approximately 9.9 % of hysterectomies were performed via laparoscopy [13]. The abdominal hysterectomy was still the most commonly performed method of hysterectomy accounting for 63 % of hysterectomies [13]. In 2003, 602,457 hysterectomies were performed in the USA, for a rate of 5.38 per 1000 women-years. Of the 538,722 hysterectomies for benign disease (rate 4.81 per 1000 women-years), the abdominal route was the most common (66.1 %), followed by vaginal (21.8 %) and laparoscopic (11.8 %) routes [14]. While the rates of abdominal hysterectomy had increased slightly from 1997 to 2003, the rates of laparoscopic hysterectomy had increased slightly [14].

In 2005, a cross-sectional analysis of the Nationwide Inpatient Sample was performed by Jacoby et al. This study revealed that among 518,828 hysterectomies, 14 % were laparoscopic, 64 % abdominal, and 22 % were performed vaginally [15]. In 2009, Cohen et al. performed a cross section analysis of the Nationwide Inpatient Sample (NIS). At that time, a total of 479,814 hysterectomies were performed in the USA in 2009, 86.6 % of which were performed for benign indications. Among the hysterectomies performed for benign indications, 56 % were completed abdominally, 20.4 % were performed in a laparoscopic manner, 18.8 % were performed vaginally, and 4.5 % were performed with robotic assistance [16]. In addition, Wright et al. reviewed the Perspective database (an all-payer, fee-supported database that represents approximately 15 % of all the hospital discharges in the USA) to identify >200,000 benign hysterectomy cases between the years 2007 and 2010; during this time frame, the proportion of hysterectomies performed with robotic assistance increased from 0.5 to 9.5 %. In this cohort, the breakdown by mode of access for hysterectomy in 2010 was as follows: 40.1 % abdominal, 30.5 % laparoscopic, 9.5 % robotic assisted, and 19.9 % vaginal [17].

According to Cohen et al., although the incidence of hysterectomy has decreased throughout the USA, the performance of laparoscopic and robotic-assisted procedures has increased [16]. In another analysis of the NIS, Wright et al. identified a decreasing trend in performance of hysterectomies as well, citing that the amount of hysterectomies performed in the USA between 1998 and 2010 had decreased by 40 %. This study also revealed disparities among minority groups and the performance of minimally invasive hysterectomies. Cohen et al. found that minority women including African-American, Asian, and Hispanic women have a 30–50 % decreased odds of undergoing minimally invasive approaches for hysterectomy. Another factor influencing the use of laparoscopy in hysterectomy is region of the USA. In the South, 40 % of hysterectomies were performed; however, 63 % of these surgeries were performed abdominally. Compared to other regions of the USA, this statistic is increased. According to this study, the lowest rate of abdominal hysterectomy is found in the West. These results have also been seen most recently in a study performed by Cooper et al. from Johns Hopkins Hospital. This study, published in 2010, analyzed the Nationwide Inpatient

Sample assessing the use of minimally invasive surgery across several specialties including gynecology and thoracic and general surgery [6•]. This study specifically addressed the actual and predicted proportion of utilization of minimally invasive surgery among hospitals included in the Nationwide Inpatient Sample [6•]. When assessing the performance of laparoscopic hysterectomy across several major institutions, an average of 13 % of hospitals participating in the Nationwide Patient Sample were performing hysterectomies via laparoscopy in 2010 [6•]. However, in those hospitals predicted to have high rates of laparoscopic surgery usage, hospital utilization rate was 33.6 %. Since the 2009 analysis of the Nationwide Inpatient Sample performed by Cohen et al., there have been no other major studies analyzing the use of laparoscopy in the field of gynecology in the USA [16].

Laparoscopy in Malignant Gynecological Conditions

Endometrial Cancer

The optimal mode of surgery for patients with endometrial cancer was clarified in the GOG-LAP2 trial. This randomized control trial revealed an improvement in short-term surgical outcomes for patients undergoing laparoscopy for endometrial cancer staging compared to those undergoing the same surgery via laparotomy [18•]. A subsequent analysis, published in 2012, reported an equivalent progression-free and overall survival rate. Laparoscopic surgical techniques have been shown to decrease patient morbidity in women who undergo surgical staging for endometrial cancer [19]. Laparoscopic-assisted surgical staging results in decreased blood loss and a shorter recovery time; however, when this surgical approach was evolving, there was a prolonged learning curve, longer operative time, and limitations in the ability to perform complex surgical procedures. As a result, laparoscopic and robotic-assisted surgery has become the accepted standard of care for endometrial cancer surgical staging. Randomized clinical trials comparing robotic-assisted to laparoscopic surgery for endometrial cancer staging are lacking, and most of the published literature is from retrospective data.

Studies have shown that it may take 20–100 surgeries for a gynecologic surgeon to reach adequate operating times. Studies have also shown that total laparoscopic surgical staging can produce adequate pelvic and para-aortic lymph node yields [20–26]. In a study performed in 2008 by Boggess et al., total robotic hysterectomy and total laparoscopic hysterectomy were seen to produce higher lymph node yields, decreased hospital stays, and a lower rate of complications [26]. Most recently in 2014, Ran et al. performed a meta-analysis assessing the utility of robotic surgery compared to laparoscopy and laparotomy in endometrial cancer [27]. The findings from this analysis revealed 22 studies that involved 4420 patients, 3403 of whom underwent both robotic surgery and laparoscopy and 1017 of whom underwent both robotic surgery and laparotomy. The estimated blood loss ($P=0.01$) and number of conversions ($P=0.0008$) were significantly lower and the number of complications ($P<0.0001$) was significantly higher in robotic surgery than in laparoscopy [27]. There was no significant difference found between robotic surgery and laparoscopy in the amount of total lymph nodes harvested during a staging surgery [27]. With the introduction of robotic-assisted surgery, studies have revealed that in endometrial cancer patients, these individuals are 12.5 times more likely to undergo a minimally invasive approach to surgical staging [11, 28–30].

Lastly, in a recent review performed by Ju et al., 13 comparative studies were analyzed comparing the use of laparoscopy and laparotomy in endometrial cancer. The results of these studies revealed that there was no difference in the survival rates between the two groups; however, there was a decrease in the amount of surgical complications noted [31].

Ovarian Malignancies

The use of laparoscopy for ovarian cancer has not been extensively studied. One study performed in 2015 by Gomez-Hidalgo et al. focused on laparoscopy in advanced stage epithelial ovarian cancers [32]. This study focused on analyzing the scientific literature regarding the use of pre-cytoreductive laparoscopy. A model was proposed known as the Fagotti scale to determine the feasibility of optimal cytoreduction based on several factors including the presence of peritoneal carcinomatosis, omental disease, bowel involvement, and mesenteric and diaphragmatic disease. The studies reviewed by this team have validated a laparoscopy-based scoring system that allows surgeons to determine with great accuracy at the time of initial diagnosis of advanced-stage ovarian cancer the likelihood that optimal cytoreduction is possible [32]. Ongoing trials in the area of ovarian cancer and the use of laparoscopy include the MISSION trial and the SCORPION trial. The MISSION trial in particular is a multicenter phase II trial currently assessing the feasibility of laparoscopic or robotic-assisted interval debulking procedure after partial or complete response to neoadjuvant chemotherapy [32]. The SCORPION trial will continue to assess the utility of pre-cytoreduction laparoscopy in FIGO stage IIIC ovarian cancer patients. The primary outcome of the study is the evaluation and comparison of early surgical complications of primary surgery and interval debulking surgery [32]. Lastly, a Cochrane review was performed in 2014 focusing on the accuracy of pre-cytoreductive laparoscopy as a predictor for optimal cytoreduction. Findings revealed that 27 to 64 % of patients were found to have too extensive disease to have a debulking laparotomy after initial laparoscopic assessment. Approximately 36 to 73 % were found to be adequate candidates for

laparotomy and these patients subsequently underwent surgery. At the time of laparotomy, 4 to 31 % had tumor appreciated following surgery, implying that these patients may have been spared laparotomy. The conclusion of this Cochrane review stated that while diagnostic laparoscopy may appear better than standard diagnostic staging alone, it should not be considered a standard procedure in clinical practice. The authors of this review do state however that there were several limitations to this study including the inability to correct for factors leading to bias [33].

Laparoscopy in Adnexal Surgery

Laparoscopy in adnexal surgery has been used for several years and is widely used in the field of reproductive endocrinology and infertility. A review of the scientific literature from 2014 to 2015 reveals the use of laparoscopy for several indications including tubal infertility, repair of distal tubal occlusions, and management of adnexal masses preventing fertility.

In the management of adnexal masses, laparoscopy may also be used. Sisodia et al. published a review in 2015 focusing on the use of laparoscopic surgery for the evaluation of adnexal masses [34]. In this review, contraindications to performing laparoscopic surgery on an adnexal mass include the ability to remove the intracorporeal mass intact avoiding spillage into the peritoneal cavity. The authors stress the use of removing the mass intact by using an Endocatch bag, or if the mass appears to be a simple cyst, drainage in an Endocatch bag may be performed to facilitate removal of the mass. However, this paper also stresses the importance of appropriate pre-operative evaluation of the patient and the adnexal mass and the performance of a mini-laparotomy if needed for intact removal of a malignant-appearing mass. Lastly, the authors of this paper review the use of managing adnexal masses in a pregnant woman. The use of laparoscopy was previously contraindicated in pregnant patients secondary to the effects on the fetus resulting in placenta insufficiency and fetal acidosis secondary to increased intra-abdominal pressure. However, it has now been studied that the optimal time for laparoscopic surgery in a pregnant woman should occur during the second trimester; the risk of spontaneous abortion is decreased and the uterine size is such that it does not prevent minimally invasive entrance to the peritoneal cavity. Laparoscopy may also occur in the third trimester. The majority of adnexal masses may be managed conservatively during pregnancy [34].

The Use of Robotic Surgery

Since the introduction of robotic surgery, there has been a decrease in the quantity of abdominal hysterectomies performed [35–38]. An ACOG Committee Opinion published in March 2015 reviewed the use of robotic-assisted surgery. Robot-assisted surgery currently is performed at more than 2025 academic and community hospital sites nationwide, with growth in excess of 25 % annually [35, 39]. Based on this Committee Opinion, robotic surgery is widely used for several different indications in the field of gynecology; however, when compared to conventional laparoscopy in randomized control trials, there has been no advantage seen in terms of morbidity from other minimally invasive approaches with increase in the cost of the procedure. The College maintains that vaginal hysterectomy should be used whenever feasible for benign disease in the setting of these increasing costs [35]. The Committee Opinion highlights four randomized controlled trials analyzing the use of robot-assisted surgery for benign gynecologic disease with laparoscopy, and similar statistics as conventional laparoscopy [35–40]. Consensus from these studies reveal that robot-assisted surgery can be performed safely in institutions with trained surgeons and that this minimally invasive approach could be considered for procedures that might otherwise require laparotomy [39].

The AAGL position statement on robotic surgery which was published in 2013 identifies situations in which robotic surgery may be superior to conventional laparoscopy, specifically in the setting of the obese patient (Narfal). As a conclusion, the AAGL position statement writes that robotic-assisted surgery and conventional laparoscopy have similar outcomes in benign gynecology and that efforts should be made in the credentialing of surgeons in this field to use robotic surgery as a means to minimalize healthcare costs [41].

In the setting of gynecologic oncology as mentioned above, robotic-assisted surgery is prevalent. Most recently in 2015, Gala et al. performed a systematic review of the literature analyzing the use of robotic-assisted surgery in gynecologic oncology. In cervical cancer patients, the use of the robot for the performance of a radical hysterectomy was linked to a decreased blood loss when compared to both conventional laparoscopy and laparotomy [42•]. In another review of the scientific literature, Sinno et al. analyzed five studies assessing the feasibility and surgical outcomes of robotic surgery in cervical cancer reporting similar findings of decreased blood loss, shorter hospital stays, and increased operating times. This study also highlighted another published study by Diaz Feijoo in 2014 that reveals that the robotic approach in cervical cancer yielded a higher number of aortic nodes (14 vs. 17 nodes, $P<0.05$) and less blood loss (90 vs. 20 mL, $P<0.05$) [43]. There is a lack of analyzed data on long-term outcomes in these patients; however, small studies have revealed similar survival rates [11]. Lastly, a study performed in 2015 by Corrado et al. focused on lymphadenectomy in cervical cancer patients using robotic-assisted surgery and found that lymph node yields were similar between conventional laparoscopy and robotic surgery [44].

In patients with endometrial cancer, robotics has been extensively studied and outcomes in terms of blood loss,

conversion rates, and lymphadenectomy outcomes have been found to be similar between conventional and laparoscopic and robotic surgery [11]. One of the largest studies performed evaluating the use of robotic surgery in endometrial cancer was performed by Gaia et al. revealing that 589 patients treated with robotic-assisted surgery experienced decreased blood loss when compared to the 396 patients who underwent conventional laparoscopy (P=0.001) and the 606 patients who underwent laparotomy (P<0.005). Perioperative complication rates and lymph node yields were similar between the three modes of surgery. Different from other studies, operative times for robotic-assisted surgery were similar to laparoscopy (219 vs. 209 min), but significantly longer than laparotomy (207 vs. 130 min, P<0.005) [11, 45].

Laparoendoscopic Single-Site Surgery

In recent years, laparoendoscopic single-site surgery (LESS), a procedure where all instruments are placed laparoscopically through one small incision compared to several incisions, is an emerging approach to minimally invasive surgery that may potentially decrease morbidity associated with abdominal incisions and may improve cosmesis. It is thought that the advantages of LESS compared to conventional laparoscopy will be as follows: faster recovery, shorter hospital stay, decreased pain medication requirements, fewer perioperative complications, and improved quality of life [46]. This approach is not only used in benign gynecology, it has also been implemented in gynecologic oncology. In a pilot study performed by Fagotti et al., LESS was found to be a feasible approach in the surgical staging of 100 patients with early endometrial cancer. These surgeons were able to perform pelvic and para-aortic lymphadenectomy. A median of 16 pelvic lymph nodes (range, 1–33) and 7 paraaortic lymph nodes (range, 2–28) were retrieved. Median operating time was found to be 129 min and estimated blood loss was 70 cc [47]. In a study performed by Boruta et al., LESS is also used for radical hysterectomy for cervical cancer. In this multicenter study, 22 patients underwent this procedure and 19 of the 22 underwent successful lymphadenectomy. A mean of 22 lymph nodes were removed. This study concluded that in select stage 1 cervical cancer patients, LESS radical hysterectomy could be performed [48].

Over the past few years, LESS has gained popularity and has been shown to be feasible in multiple studies [46, 49, 50]. Many of these studies are retrospective studies of small cohorts. The use of LESS in obese versus non-obese women was analyzed in a multicenter retrospective case-control study published in 2015. In this study, 115 women underwent LESS hysterectomy, 43 were obese, and 72 were non-obese. There were no significant differences found in operative time, conversion to conventional laparoscopy, early post-operative complications, or intraoperative complication rates [49].

Most recently in 2015, a study focusing on the feasibility of robotic single-site surgery was performed by Scheib et al. This study was a single-institution, prospective analysis of 40 women treated with robotic LESS on the benign gynecology and gynecological oncology services from June 2013 to March 2014. Procedures performed included total laparoscopic hysterectomy, laparoscopic supracervical hysterectomy, salpingo-oophorectomy, ovarian cystectomy, excision of endometriosis, and a combined case of total laparoscopic hysterectomy and cholecystectomy. Operating time was found to be on average 134 min with only one conversion to conventional robotic surgery and one extra port placed in one patient. This analysis concluded that multiple gynecologic procedures could be safely performed via robotic LESS.

At this time, further studies are needed to determine the ideal gynecological procedures to be performed via robotic single-site surgery and to assess the benefits and costs of the robotic approach compared with multiport robotic and conventional laparoscopic approaches [51].

Conclusion

Level I data demonstrate the clinical superiority of minimally invasive gynecologic surgery over open abdominal surgery. Although rates of minimally invasive surgery are rising in the USA, they are still not optimal. Factors influencing the use of laparoscopy in the USA include hospital type and location, patient socioeconomic status, geographic region, and surgeon training. The general consensus among ACOG and the AAGL states that minimally invasive surgery should be utilized whenever possible; however, especially in the setting of robotic-assisted surgery in benign gynecology, more studies comparing minimally invasive modalities should be performed. In the field of gynecologic oncology, surgical staging and radical procedures are more frequently performed in this manner with excellent clinical outcomes and no compromise to oncologic outcome. Further studies are needed to address potential disparities in utilization of minimally invasive surgery nationwide.

Compliance with Ethics Guidelines

Conflict of Interest Amanda Ramos and Amanda N. Fader declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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