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CLINICAL ARTICLE

Risk factors for robotic gynecologic procedures requiring conversion to other surgical procedures

Cecile A. Unger *, Mark P. Lachiewicz, Beri Ridgeway

Obstetrics, Gynecology, and Women's Health Institute, Center for Urogynecology and Pelvic Reconstructive Surgery, Cleveland Clinic, Cleveland, OH, USA

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ABSTRACT

Objective: To determine the incidence of, and risk factors for, conversion from robotic gynecologic procedures to other procedure types. *Methods:* A retrospective cohort study included data from women who underwent any robotic gynecologic procedures between January 1, 2011 and December 31, 2012 at a tertiary care referral center in the USA. Demographic data, perioperative data, and surgeon experience (monthly case volume) data were retrieved; potential risk factors were compared between robotic procedures that were converted to other procedures and those completed as robotic procedures. *Results:* There were 942 robotic procedures during the study period. Conversion from robotic to any other type of procedure was recorded for 47 (5.0%, 95% confidence interval 3.8–6.6) procedures and robotic-to-open-surgery conversion occurred in 16 (1.7%, 95% confidence interval 1.0–2.7) procedures. Conversion from robotic surgery to another approach was associated with higher body mass index ($P < 0.001$), previous laparotomy ($P = 0.042$), and surgeons having a lower monthly robotic surgical case volume ($P = 0.011$). Asthma ($P = 0.008$), intra-operative bowel injury ($P < 0.001$), intra-operative vascular injury ($P = 0.003$), and single-port robotic surgery ($P = 0.034$) were associated with increased odds of requiring conversion from robotic procedures. *Conclusion:* The overall incidence of conversion from robotic surgery to laparotomy was low. Higher body mass index, previous laparotomy, history of asthma, using a single-port approach, and surgeon case volume were associated with the risk of conversion.

1. Introduction

Minimally invasive surgery has been increasingly utilized in the field of gynecology in recent decades. Minimally invasive techniques confer many benefits, including a shorter duration of hospital admission, a faster recovery and return to daily activities, lower intraoperative blood loss, and reduced postoperative pain [1–3]. During the last 10 years, the use of robotic-assisted surgery has substantially increased, beginning with urologic procedures, before expanding to include gynecologic surgery and other specialties [4]. In 2005, the US Food and Drug Administration formally approved the use of the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) for gynecologic procedures. At the time of approval, fewer intraoperative and major adverse events, a faster learning curve, and a lower rate of conversion to open procedures compared with conventional laparoscopy had been reported [5].

Consequently, robotic surgery gained wide acceptance with many academic and community hospitals throughout the USA viewing robotics as an important part of gynecologic practice. Robotic-assisted laparoscopic surgery has become very popular in gynecology, with some surgeons believing it to be a platform that can help overcome challenges encountered with conventional laparoscopy; however, randomized controlled trial data comparing robotic surgery with conventional laparoscopy are very limited [6]. The evidence available demonstrates that although robotic-assisted surgery is associated with increased operating times and cost compared with conventional laparoscopy [1], the two techniques are comparable in terms of perioperative outcomes, intraoperative complications, duration of hospital stay, and the incidence of requiring conversion to open surgery [7–10].

Paraiso et al. [7] demonstrated, in a randomized trial, that there was no difference in the rate of conversion to laparotomy between robotic-assisted and conventional laparoscopic sacrocolpopexy. Conversely, other studies have reported the incidence of conversion to be significantly lower in robotic surgical procedures (1.7% vs 6.2%) [10]. Currently, there are few data describing patient and surgeon risk factors affecting the need to convert of robotic-assisted gynecologic procedures to open abdominal procedures. Understanding these factors is important and could help providers make better decisions regarding the appropriate surgical approach for their patients.

In the largest study investigating conversion risk factors to date, Jones et al. [11] performed a case-control study comparing robotic surgical procedures requiring conversion to laparotomy with those completed robotically. In a multivariate analysis, the authors found that

* Corresponding author at: 9500 Euclid Ave/A81, Obstetrics, Gynecology, and Women's Health Institute, Cleveland Clinic, Cleveland, OH 44195, USA. Tel.: +1 216 445 0439.
E-mail address: ungerc@ccf.org (C.A. Unger).

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non-white ethnicity, bowel injury, and increased body mass index (BMI, calculated as the weight in kilograms divided by the square of height in meters) were significantly associated with increased risk of robotic surgical procedures requiring conversion. The authors investigated several surgical and patient factors associated with the need for conversion; however, surgeon-specific factors such as surgical experience and case volume were not assessed. The aim of the present study was to determine the overall incidence of conversion to open surgery for procedures initially planned to be robotic-assisted procedures, and to determine surgeon and patient risk factors contributing to conversion.

2. Materials and methods

The present retrospective cohort study enrolled all women who underwent robotic-assisted laparoscopic gynecologic procedures at a tertiary care center in the USA between January 1, 2011 and December 31, 2012. Potential participants were identified using postoperative current procedural terminology codes for any laparoscopic gynecologic surgery (Box 1). Patients' detailed operative records were reviewed and if a robotic surgical procedure was planned they were included in the study. Patients who underwent concomitant non-gynecologic procedures (e.g. abdominal hernia repair) were included. The institutional review board at the study institution approved the present study and waived obtaining informed consent from participants.

Following the identification of eligible patients, electronic medical records were examined for demographic, preoperative, perioperative, and postoperative data. The preoperative variables analyzed were age, parity, BMI, smoking history, previous laparotomy (including cesarean delivery), preoperative uterine size (based on physical examination and/or volume on imaging), adhesions reported from previous surgeries, history of endometriosis, history of inflammatory bowel disease and/or diverticulitis, any cancer diagnosis, and medical co-morbidities.

Patients were divided into two groups based on whether the surgical procedure was completed robotically or if it was converted to another type of procedure, and the two groups' data were compared.

Box 1
Procedural terminology codes for laparoscopic gynecologic surgical procedures.

57425 = laparoscopic colpopexy
58570 = total laparoscopic hysterectomy, uterus ≤250 g
58571 = total laparoscopic hysterectomy, uterus ≤250 g with bilateral salpingo-oophorectomy
58572 = total laparoscopic hysterectomy, uterus >250 g
58573 = total laparoscopic hysterectomy, uterus >250 g with bilateral salpingo-oophorectomy
58541 = laparoscopic supracervical hysterectomy ≤250 g
58542 = laparoscopic supracervical hysterectomy, uterus ≤250 g with bilateral salpingo-oophorectomy
58543 = laparoscopic supracervical hysterectomy >250 g
58544 = laparoscopic supracervical hysterectomy, uterus >250 g with bilateral salpingo-oophorectomy
38571 = laparoscopic lymphadenectomy
38572 = laparoscopic lymphadenectomy
58548 = laparoscopic radical hysterectomy with pelvic lymphadenectomy
58545 = laparoscopic myomectomy
58546 = complex laparoscopic myomectomy
58661 = laparoscopic removal of adnexa
58720 = laparoscopic removal of ovary/tube
58740 = laparoscopic revision of fallopian tube
58752 = laparoscopic revision of ovarian tube
58750 = tubal anastomosis

Conversion was defined as any robotic procedure that was converted to open abdominal surgery, mini-laparotomy, conventional laparoscopy, or vaginal surgery. Conversion was further categorized based on whether conversion occurred to complete the planned treatment (it could not be completed robotically) or for specimen removal only; additionally, conversion was categorized according to whether the procedure was initially performed robotically and then converted, or if it was planned as a robotic surgery but the surgical approach was changed without ever docking the robot.

Indications for converting procedures were recorded based on the content of the detailed operative notes dictated by the surgeon. Operative notes and medical records were used to identify intraoperative adverse events, including vascular injury, cystotomy, ureteral injury, bowel injury, estimated blood loss, and need for blood transfusion.

Data were collected on the experience of each surgeon who performed procedures included in the present study (regardless of subspecialty), including year of robotic certification for each surgeon, their case volume (defined as the average monthly number of laparoscopic and robotic procedures from a 3-year period [2010–2012]), and the number of laparoscopic and robotic surgical procedures performed during the 1 year prior to the study period and the study period itself.

Categorical data were reported as absolute numbers and percentages with 95% confidence intervals; continuous data were reported as the mean $\pm$ SD and as medians with ranges. Risk factors were only examined from procedures where a conversion from robotic surgery was necessary to complete a procedure, with risk factors not included from procedures where conversion occurred for specimen removal only.

Parametric continuous data were compared using the Student t test; the Mann–Whitney U test was used for the comparison of nonparametric data, and the χ^2 test was used for categorical data. A logistic regression was performed to control for surgeon subspecialty, monthly surgical case volume, and variables that differed significantly between converted and non-converted procedures in a bivariate analysis. Associations between variables were assessed using the Pearson product-moment correlation coefficient. All statistical tests were two-sided and $P \leq 0.05$ was considered significant. JMP version 10.0 (SAS Institute, Cary, NC, USA) was used for all statistical analyses.

3. Results

During the study period, 2175 patients underwent laparoscopic gynecologic procedures at the study institution; of these procedures, 942 were robotic-assisted procedures that were performed by 14 surgeons (five gynecologic oncologists, four urogynecologists, one reproductive endocrinology and infertility specialist, and four generalist obstetrician gynecologists). Of the robotic-assisted procedures, 590 (62.6%) were gynecologic oncology procedures, 242 (25.7%) were general obstetric gynecology procedures, 86 (9.1%) were urogynecology procedures, and 24 (2.5%) were reproductive endocrinology procedures. Of the robotic procedures, 36 (3.8%, 95% confidence interval [CI] 2.8–5.2) were converted to mini-laparotomy at the end of the procedure for specimen removal only. Among the robotic surgical procedures, 47 (5.0%, 95% CI 3.8–6.6) were converted to other procedure types for completion; 16 (1.7%, 95% CI 10,-2.7) were converted from robotic to open procedures, 13 (1.4%) were planned as robotic procedures but the robot was never docked and the procedures were initially performed as conventional laparoscopic procedures before being converted to open procedures, 12 (1.3%) were converted from robotic procedures to conventional laparoscopic procedures, 3 (0.3%) were robotic procedures that were converted to mini-laparotomies, 2 (0.2%) procedures were planned to include robotic assistance but were performed as open abdominal procedures without laparoscopic ports being placed, and 1 (0.1%) procedure was initially performed robotically before being converted to use a vaginal approach (Fig. 1).

The indications for converting procedures that were recorded included 16 (34.0%) conversions because the procedure was too difficult