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Major Perioperative Complications of Benign Gynecologic Procedures at a University-Affiliated Hospital

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ABSTRACT

Background: With the increasing use of minimally invasive techniques for gynecologic procedures, women are at a low risk for perioperative complications. The purpose of this study was to determine the incidence of and risk factors for major intra or postoperative complications among women undergoing benign gynecologic surgeries.

Methods: We conducted a retrospective observational study of all women who underwent benign gynecologic surgery in 2016-2017 at a University-Affiliated community hospital. Pregnant women, malignancy cases, and hysteroscopic or minor vulvar procedures were excluded. Primary outcome was composite intraoperative and/or 30-day postoperative complications requiring medical or surgical management. Logistic regression identified significant patient, peri-operative and surgeon risk factors associated with complications.

Results: Of 975 patients included, 53 patients experienced major intra or postoperative complications (5.4%). Mean age was 47.7 ± 13.8 years. Mean BMI was 27.1 ± 5.8 kg/m2. Prior abdominal surgery (laparotomy or laparoscopy) (adjusted odds ratio [OR]= 2.01, 95%CI 1.05-3.83) and emergency surgery (adjusted OR= 19.54, 95%CI 2.99-127.54) were significantly associated with major complications. Surgeon volume of 1-2 operative days per month (adjusted OR=0.30, 95%CI 0.10 - 0.87) and age 40-64 years (adjusted OR=0.24, 95%CI 0.11- 0.56) had a protective effect on the risk of major complications.

Conclusion: Among patients in our sample, 5.4% experienced major complications from a benign gynecologic surgery. Complications from benign gynecologic surgery are rare, even in the absence of robotic equipment. Center-specific data and a discussion of the increased morbidity associated with with prior abdominal surgery and emergency surgery should be considered for pre-operative patient counselling.

KEYWORDS

Gynecologic surgical procedures, Postoperative complications, Intraoperative complications, Minimally invasive surgery, Benign gynecology

1 | INTRODUCTION

Major complications are infrequent after gynecological procedures, and are occurring less commonly as minimally invasive techniques are increasingly being used. (1) Minimally invasive techniques also improve recovery times and shorten hospital stays. (2) In fact, composite major intra and postoperative complications rates in laparoscopic and vaginal hysterectomies were estimated at 1.4% and 1.9%, respectively. (3) Similarly, the frequency of major intraoperative complications in laparoscopic adnexal surgery has been evaluated at 0.8% among women who had not previously undergone a hysterectomy. (4) Although rare, major complications such as hemorrhage, bowel or urinary tract injuries and vaginal cuff dehiscence still arise and often require additional surgical or pharmacological interventions, resulting in higher morbidity and mortality risks. (5-7)

Risk factors for complications include multiple surgeon and center-specific factors. Surgeon volume has repeatedly been found to be a predictive factor, as surgeries performed by high-volume surgeons are usually associated with shorter hospitalizations, fewer perioperative complications, and fewer conversions to laparotomy. (8, 9) In addition, complication rates per center can vary due to access to various minimally invasive equipment types and by center condition expertise. For example, access to robotic equipment for benign gynecologic surgery is limited to non-existent in most Canadian centers, with only a few facilities benefiting from these technologies. (10, 11) When discussing complication rates for preoperative patient counseling, center-specific data would be optimal, as it encompasses all these technical factors. However, this can be difficult to collect and provide. Quality improvement programs frequently perform departmental audits and can provide a tool to collect such information.

Few recent studies describe overall major intra or postoperative complications risk of benign gynecologic surgery. The Canadian context with limited robotic surgery access in most centers may differ from other published North American rates. We aimed to determine the incidence of major intra or postoperative complications in women undergoing benign gynecologic procedures at a Canadian university-affiliated hospital. Secondly, we sought to evaluate the association between patient, surgeon and operative factors and surgical complications at our center.

2 | METHODS

We performed a retrospective chart review of all women who underwent benign gynecological surgeries at a Canadian university-affiliated center, in 2016 and 2017. Patients were excluded for pregnancy, undergoing hysteroscopic or minor vulvar procedures, or malignancy. The sample size was determined by the number of cases meeting inclusion criteria during the period studied. We classified cases by diagnosis, procedure and approach (vaginal, laparoscopic or laparotomy). We collected patients' age, body mass index, birthplace, smoking status, comorbidities, prior surgeries, surgeon, admission type, conversion of approach, operative time, pre-operative hemoglobin, peri-operative prophylactic antibiotics administration, thromboprophylaxis (in the form of heparin or low molecular weight heparin received pre-operatively +/- post-operatively), and diagnosis severity. Surgeon volume for the 20 surgeons at our center was determined based on compiled data, and subdivided into 3 categories (high, medium and low volume) based on the mean number of operative days per month per surgeon. We used the Charlson Comorbidity Index (CCI) to report on comorbidities. (12) Formal approval by the local Research Ethics Committee was obtained prior to the start of the study.

Risk factors were categorized. Age was grouped into young adults (18-39), middle-aged (40-64) and senior adults (65 years old or greater). Obesity was defined as a body mass index higher or equal to 30 kg/m2 . (13) Smoking history was divided as current cigarette smoker vs. non-smoker or ex-smoker. The CCI was used to measure the significance of patient comorbidities. (12) Operative time longer than 180 minutes was considered a risk factor. (6, 14) Anemia was defined as a hemoglobin level lower than 120 g/L. (15) A large uterus and/or fi-

Characteristics	Values	# missing values
Pre-operative patient factors		
Age (years), mean (SD)	47.7 (13.8)	0
Place of birth, n (%)		2
Canada	515 (52.9)	
Elsewhere	458 (47.1)	
BMI*, mean (SD)	27.1 (5.8)	107
Current smoker, n (%)	109 (11.5)	26
Charlson Comorbidities Index, mean (SD)	0.8 (1.2)	23
At least one prior pelvic surgery, n (%)	401 (42.0)	21
At least one non-gynecological prior abdominal surgery, n (%)	249 (26.2)	26
Peri-operative factors		
Admission type, n (%)		0
Planned	948 (97.2)	
Emergency	27 (2.8)	
Approach of surgery, n (%)		0
Vaginal approach	261 (26.8)	
Laparoscopy	542 (55.6)	
Laparotomy	172 (17.6)	
Conversion to laparotomy from laparoscopy or vaginal approach, n (%)	19 (2.4)	
Operative time (minutes), median (IQR)	87 (50, 147)	
Pre-operative hemoglobin (g/L), mean (SD)	130.4 (14.3)	61
Prophylactic antibiotics, n (%)		4
Recommended, received	581 (59.8)	
Recommended, not received	83 (8.6)	
Not recommended	307 (31.6)	
Received Thromboprophylaxis, n (%)	462 (47.6)	4
Main diagnosis (1 to 7) and severity		
1-Fibroids, n (%)	261 (26.8)	
Weight of pathology specimen (g), median (IQR)	347 (178, 690)	7
2-Endometriosis, n (%)	52 (5.3)	
Stage, median (IQR)	4 (3, 4)	13
3-Prolapse, n (%)	231 (23.7)	
Stage, median (IQR)	3 (2, 3)	16
4-Ovarian cyst	114 (11.7)	
Size (cm), mean (SD)	4.1 (2.5)	4
5-Stress urinary incontinence, n (%)	62 (6.4)	
6-Family planning, n (%)	103 (10.6)	
7-Other, n (%)†	152 (15.6)	

Data is presented as n (%), mean (SD=Standard Deviation); or median (IQR=Inter-quartile range, 1st and 3rd quartiles) *BMI=Body Mass Index † The 'other' diagnosis group includes adenomyosis, abnormal bleeding (without concurrent diagnosis, fibroids or adenomyosis), chronic pelvic pain and history of cancer/prophylaxis.)

TABLE 1 Patient and Surgery Characteristics (n=975)

Procedures:	N	Intraoperative complications n (%)	Postoperative complications n (%)	Overall rate of complications n (%)
Prolapse repair without hysterectomy (any route) (with or without incontinence procedure)	139	1 (0.7)	3 (2.2)	4 (2.9)
Prolapse repair with hysterectomy (any route)	89	0 (0.0)	4 (4.5)	4 (4.5)
Incontinence procedure alone (without prolapse repair)	59	1 (1.7)	0 (0.0)	1 (1.7)
Laparoscopic hysterectomy	144	4 (2.8)	10 (6.9)	14 (9.7)
Vaginal hysterectomy without prolapse indication	4	1 (25.0)	0 (0.0)	1 (25.0)
Abdominal hysterectomy	104	8 (7.7)	6 (5.8)	13 (12.5)
Laparoscopic myomectomy	17	0 (0.0)	0 (0.0)	0 (0.0)
Abdominal myomectomy	49	3 (6.1)	6 (12.2)	7 (14.3)
Laparoscopic adnexal surgery (includes family planning procedures)	280	0 (0.0)	1 (0.4)	1 (0.4)
Open adnexal surgery	10	2 (20.0)	1 (10.0)	3 (30.0)
Resection of endometriosis	25	1 (4.0)	1 (4.0)	1 (4.0)
Diagnostic laparoscopy	13	0 (0.0)	0 (0.0)	0 (0.0)
Other *	62	1 (1.6)	3 (4.8)	4 (6.5)

Some patients had multiple complications *The 'other' surgeries group includes procedures such as pelvic abscess drainage, rectovaginal fistula repair, urinary fistula repair and periurethral cyst removal.

TABLE 2 Rates of Complications by Procedure Type

broids was defined as weighing more than 500 g. (16) Case complexity was defined as endometriosis stage 3-4, fibroids >500 g or adnexal cyst size >10 cm. Finally, surgeon volume was categorized based on the number of operative days per month into low (<1 day), medium (1-2 days) and high (>2 days) volume using observed tendencies in our sample. The majority of surgeons in the sample operate exclusively at this center, thus the volume recorded is representative of overall operative time. The number of OR days was used to represent both surgical case volume as well as expertise in complexity. Some surgeons perform more complex surgeries or operate on patients with more comorbidities which can limit the number of cases in one day.

The primary outcome was composite major intraoperative and/or 30-day postoperative complications. The Clavien-Dindo classification was used to define major complications, more generally as grade II and above. (17) Therefore, major complications were defined as requiring transfusions, administration of drugs other than antiemetics, antipyretics, analgesics, diuretics and electrolytes, surgical intervention or intensive care unit management, or resulting in mortality. (17) Hemorrhage was considered a major complication if it required a blood product transfusion, or if radical measures were used such as an artery ligation, prolonged pelvic packing, or re-operation. (2) Major infections, including wound infections, pelvic abscesses, pneumonia and sepsis, were included if they required antibiotics or abscess drainage; simple urinary tract infections were excluded. (18) Major bowel injury and rectovaginal fistula were defined as requiring intraoperative or postoperative surgical intervention and/or antibiotics. (6, 19) Small bowel obstructions were also considered major complications. (20) Urinary tract injuries or urogenital tract fistulas were considered if they required a nephrostomy tube,

Complications	Vaginal (n=261)	Laparoscopy (n=542)	Laparotomy (n=172)	All approaches (n=975)
Overall	11 (4.2)	18 (3.3)	24 (14.0)	53 (5.4)
Intraoperative complications				
Any complication	2 (0.8)	6 (1.1)	14 (8.1)	22 (2.3)
Hemorrhage	1 (0.4)	2 (0.4)	8 (4.7)	11 (1.1)
Bowel injury	1 (0.4)	0 (0.0)	4 (2.3)	5 (0.5)
Urinary tract injury	0 (0.0)	4 (0.7)	3 (1.7)	7 (0.7)
Postoperative complications				
Any complication	9 (3.5)	12 (2.2)	14 (8.1)	35 (3.6)
Hemorrhage	1 (0.4)	6 (1.1)	4 (2.3)	11 (1.1)
Bowel injury (not recognized intraoperatively)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Urinary tract injury (not recognized intraoperatively)	1 (0.4)	0 (0.0)	1 (0.6)	2 (0.2)
Pelvic abscess	2 (0.8)	1 (0.2)	1 (0.6)	4 (0.4)
Wound infection	1 (0.4)	1 (0.2)	3 (1.8)	5 (0.5)
Pneumonia	0 (0.0)	0 (0.0)	1 (0.6)	1 (0.1)
Sepsis or septic shock	1 (0.4)	1 (0.2)	0 (0.0)	2 (0.2)
Deep vein thrombosis	0 (0.0)	1 (0.2)	1 (0.6)	2 (0.2)
Pulmonary embolus	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.1)
Urogenital tract fistula	0 (0.0)	0 (0.0)	1 (0.6)	1 (0.1)
Rectovaginal fistula	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.1)
Small bowel obstruction	0 (0.0)	0 (0.0)	1 (0.6)	1 (0.1)
Vaginal cuff dehiscence	0 (0.0)	2 (0.4)	0 (0.0)	2 (0.2)
Other	2 (0.8)	0 (0.0)	2 (1.2)	4 (0.4)

Note: mortality, hernia, myocardial infarction, stroke, coma, cardiac morbidity, respiratory morbidity and renal morbidity did not occur *some patients had multiple complications

TABLE 3 Rates of Each Complication by Approach

a ureteral stent, or intraoperative or postoperative surgical intervention. (21, 22) Thus, bladder perforations requiring no intervention were not included (as in anti-incontinence procedures). Vaginal cuff dehiscence was defined as needing surgical repair. (2) Renal morbidity was defined as acute or progressive, requiring dialysis or a creatinine rise of more than 2 mg/dL. (18) Respiratory and cardiac morbidity (other than myocardial infarction) were included if they required an intensive care unit stay. (18) Pulmonary embolism, deep vein thrombosis, stroke, myocardial infarction, comatose state longer than 24 hours, and mortality were also considered to be major complications. (18)

Descriptive statistics were used to report the results. The rate of each binary outcome (1-Intraoperative complication, 2-Postoperative complication, 3-Overall complication) was computed for 17 potential baseline risk factors. These factors were divided in 3 blocks of variables: 1) pre-operative patient variables, 2) peri-operative variables, and 3) surgeon volume. For the 'Overall complication' outcome, logistic regression was performed for each risk factor. (23) Multivariable logistic regression was performed for each block of variables, and the Bayesian Information Criterion (BIC) was used to select the best model by minimizing the BIC. (24) The final multivariable logistic model included the variables retained in each block. A sensitivity analysis was also performed to capture the multilevel aspect of the data

(patient nested in surgeon). The Generalized Estimating Equations (GEE) approach was used to handle the correlation; surgeon was treated as a random intercept. (25) The Intra-class Correlation Coefficient (ICC) was computed to measure the proportion of the outcome's total variance explained by the surgeon. (26) For all models, Odds Ratios (OR) and 95% Confidence Intervals (CI) were computed from the estimates of the model. A subanalysis including only hysterectomies (all approaches included) was also performed. Statistical analysis was performed using SAS University Edition (SAS Institute Inc, North Carolina).

Missing values were accounted for in different ways depending on their frequency. If there were less than 10 missing values (<1%), those were imputed with the mode. If there were 10 or more missing values, those were coded as a 'missing' category and included in the regression model. Missing BMI values were coded as normal (<30 kg/m2 category) as high BMIs are generally recorded in the operative report for physician billing purposes. Thus, it is reasonable to assume charts recording no BMI correspond to women with a BMI <30 kg/m2. Similarly, missing hemoglobin values were coded as normal (>120 g/L category). For low-risk procedures such as tubal ligation or small adnexal cysts removal in women below the age of 40 without significant medical history, the patient is considered healthy and does not get assessed at the pre-operative clinic, which would include blood work. Therefore, if no preoperative hemoglobin value was measured, we assumed that the patient's hemoglobin is likely greater than 120 g/L.

3 | RESULTS

1757 women underwent gynecologic surgery at our tertiary care hospital in 2016 and 2017. 782 were excluded for pregnancy, malignancy and hysteroscopic or minor vulvar procedures. 975 patients were included in the final analysis. Patient demographics are presented in Table 1. A majority of procedures were performed laparoscopically (55.6%) (26.8% vaginal and 17.6% laparotomy). The most common comorbidities were diabetes, chronic kidney disease, chronic obstructive pulmonary disease and hepatic disease. Overall, 53 women (5.4%) had a surgical complication. Table 2 shows complication rates by procedure type. The most common intraoperative complications included hemorrhage (1.1%), bowel injury (0.5%), and urinary tract injury (0.7%). Postoperative complications were most frequently hemorrhage (1.1%), wound infection (0.5%), and pelvic abscess (0.4%). Mortality, hernia, myocardial infarction, stroke, coma, cardiac morbidity, respiratory morbidity, and renal morbidity did not occur. Table 3 shows the rates of each complication by approach.

Univariate and multivariate analyses of risk factors and their impact on complication rates are shown in Table 4. Univariate analysis of the primary outcome (composite intraoperative and/or 30-day postoperative complications) showed prior abdominal surgery (OR= 2.06, 95%CI 1.16-3.67), admission through emergency (OR= 3.19, 95%CI 1.06-9.59), laparotomy approach (OR= 3.69, 95%CI 1.76-7.74), conversion to laparotomy (OR= 8.93, 95%CI 3.25-24.53), and complexity (OR=2.98, 95%CI 1.60-5.52) to be significant factors when treated independently. None of the missing values categories showed an association to the outcome. BMI and hemoglobin showed higher percentage of missing data (11% and 7%). Four variables showed a rate of 3% of missing data and three variables showed a rate less than 1%. BMI was not significant when obesity was defined as a BMI higher or equal to 30 kg/m2. The extreme obesity cut-off of 40 kg/m2 did not return a significant result either, although this sample contained few patients.

For the multivariate analysis (Table 4), age, smoking status, comorbidities (CCI>0), prior abdominal surgeries, surgeon volume, admission type, approach, conversion to laparotomy, peri-operative prophylactic antibiotics, thromboprophylaxis, and complexity were included in the final multivariate model. This model showed that prior abdominal surgery (laparotomy or laparoscopy) (adjusted OR=2.01, 95%CI 1.05- 3.83), and emergency surgery (adjusted OR=19.54, 95%CI 2.99-127.54) were significantly associated with increased risk of major com-

plications. Of note, 4/27 (14.8%) of emergency surgeries resulted in complications, compared to 49/948 (5.2%) of planned procedures. Age of 40-64 years had a protective effect on complication rates (adjusted OR= 0.24, 95%CI 0.11- 0.56), compared to both younger and older women. The relationship between surgeon volume and complications was U-shaped, with surgeons operating 1 to 2 days per month having the lowest complication rates (adjusted OR= 0.30, 95%CI 0.10 - 0.87). The sensitivity analysis (GEE model, data not shown) reveals similar findings, the proportion of the variation explained by adding the surgeon as a random intercept variable in the final multivariable model was weak and non-significant (ICC=1%). Finally, the sub-analysis of only hysterectomies (all approaches included) did not return significant risk factors. Of note, hysterectomies are mainly performed when medical management failed.

4 | DISCUSSION

We reported an overall risk of major intra- or postoperative complication of 5.4% after benign gynecologic surgery at a university-affiliated center, with a majority of procedures being performed via minimally invasive approach. Prior abdominal surgery and emergency surgery were unsurprisingly associated with an increased complication risk. The rates measured appear to be consistent with prior literature on gynecologic surgical complications.

In Erekson's large scale study on postoperative complications following gynecologic surgery based on American College of Surgeons National Surgical Quality Improvement Program (ASC-NSQIP) data on over 22,000 women, the frequency of complications from benign procedures ranged from 1.7% for prolapse procedures to 3.5% for benign hysterectomies, with an overall 3.7% rate of major postoperative complications. (18) We similarly found 3.6% postoperative complications. However, some of our outcome definitions differed, as Erekson's study did not include urinary tract injuries, which accounted for 5.7% of our reported post-operative complications. (18) In addition, the authors did not mention how many surgeries were robotically-assisted; but similar to our population, a large number of surgeries were performed via minimally invasive techniques. Another study, by Margulies et al., of close to 110,000 hysterectomies based on retrospective ASC-NSQIP data, found a rate of postoperative complication of 6% after laparoscopic and 14% after abdominal hysterectomy. (1) These authors do report that laparoscopy and robotic procedure codes used for their analysis cannot be distinguished, hence a significant proportion of their laparoscopic cases may have been robotically-assisted. (1) Despite the lack of robot use at our center, we similarly found a postoperative complication rate of 9.7% after laparoscopic and 12.5% after abdominal hysterectomy. Moreover, the laparotomy approach has been associated with an increased risk of complications in previous literature and was not a surprising finding in our univariate analysis, although it became non-significant in the multivariate analysis. (1, 2, 18)

Although it has been observed, the association between emergency surgery and increased risk of perioperative complications in benign gynecology has not been, to our knowledge, studied extensively. It has been reported for emergency general surgery. (18, 27) Havens' study on the complications of urgent general surgery concluded that emergency surgery is an important risk factor for complications. (27) They also reported that pre-operative patient characteristics such as comorbidities and physiological status do not solely explain the high complication rates in urgent cases. (27) Surgeries in comorbid patients may be delayed for medical optimization or trial of conservative management, contributing to the increased morbidity. (28) Havens et al. concluded that emergency general surgery should be a target for quality improvement programs. (27) Likewise, as highlighted in our study and reinforced by literature, surgical history is an important determinant of complication risk, notably because it can distort pelvic anatomy and cause adhesions. (2, 5, 29)

In our study, patients aged 40 to 64 years were less likely to get complications from their surgeries than younger and older patients. In prior literature, increasing age is generally associated with higher complication

rates (18, 30) and longer operative times. (1) Surgeries on older patients are also less likely to be done via minimally invasive techniques. (8) One hypothesis as to why younger patients in our sample had more complications than middle-aged patients is that the 18-39 year old group underwent more myomectomies and laparotomies, which are procedures that resulted in more complications. For example, 18.5% of patients aged 18-39, compared to 4.4% of patients aged 40-64, underwent myomectomies. In the younger group, 19.9% had a laparotomy compared to only 10.3% in the middle-aged group. We also hypothesize that the senior adult group was more likely to have a complication from their comorbidities than from the type of surgery. These hypotheses could not be verified in our study.

The finding of a U-shaped relationship between surgeon volume and complication was unexpected. This finding does not seem to be related to a hypothesis of high-volume surgeons performing more complex procedures. By defining complex procedure as a diagnosis of endometriosis stage 3-4, fibroids/uterus 500g or adnexal cyst size 10 cm, high-volume surgeons performed 30.8% of complex procedures, which cannot solely explain the association. Nonetheless, 82.9% of procedures on women aged 65 and over and 87.7% of operations on women with comorbidity scores 3 were performed by high-volume surgeons. Thus, high-volume surgeons seem to have operated on older patients with more comorbidities who were more likely to have complications, which explains their higher complication rates than medium-volume surgeons. Surgeon training and experience could not be assessed in our study.

Sub-specialization fellowship training and high surgical volume have previously been linked to improved gynecological surgical outcomes. (33-35) Conversely, this additional training narrows a physician's scope of practice and, on a larger scale, could limit access to routine or preventive health care from general Obstetricians Gynecologists. (36) Many surgeons in our study are subspecialty-trained in urogynecology and/or minimally invasive surgery, which may have contributed to our overall low rates of complications. However, surgeon training and/or experience was not a factor assessed in this study.

Our study has a few limitations. Most importantly, as the data was collected retrospectively, incomplete patient files lead to missing values which may have disturbed the measured associations of risk factors on outcomes. BMI values were missing most commonly (11% of charts). In addition, patients may have presented to another center with postoperative complications, which our data collection method would not have recognized. Moreover, some factors, notably socio-economic factors, were not studied and could impact outcomes. (8) Lastly, reliable information on the use of medications for pre-operative optimization was not available to us, and thus could not be included in the study. For example, preoperative use of gonadotropin-releasing hormone agonist to reduce fibroid size and iron supplements to improve anemia have been shown to reduce blood transfusions and postoperative complications in gynecologic surgery. (40, 41) Therefore, the administration of these medications likely influenced outcomes, but it could not be measured in this study.

In conclusion, the rate of major intra- or postoperative complications related to benign gynecologic procedures at a university-affiliated urban hospital was 5.4%. Prior abdominal surgery (laparotomy or laparoscopy) and emergency surgery were significantly associated with increased risk of major complications. Future research could explore quality improvement targets for emergency surgeries specifically, such as patient comorbidities, prioritization of these procedures, and associated delays. Our findings also demonstrate that complications arising from benign gynecologic surgery are rare, even in the absence of robotic equipment. Surgeons should consider the use of center-specific data and of these factors when counseling patients about the risk of adverse outcomes.

	Intra or post operative complications	
	Univariate logistic models	Multivariable logistic model
Variables	**OR [95% CI]**	**OR [95% CI]**
Pre-operative patient factors		
Age (years)		
18-39	1.00	1.00
40-64	**0.53 [0.29, 0.96]**	**0.24 [0.11; 0.56]**
≥65	0.66 [0.29, 1.51]	0.49 [0.10;2.42]
Born outside Canada		
No	1.00	
Yes	1.01 [0.58, 1.76]	
BMI*		
<30 kg/m2	1.00	
≥30 kg/m2	0.98 [0.51; 1.90]	
Current smoker		
No	1.00	1.00
Yes	0.46 [0.14, 1.51]	0.49 [0.13; 1.76]
Charlson Comorbidities Index (CCI)		
CCI = 0	1.00	1.00
CCI = 1, 2	0.59 [0.29, 1.20]	0.61 [0.24; 1.58]
CCI ≥ 3	0.67 [0.26, 1.75]	0.33 [0.06; 1.79]
Prior pelvic surgeries		
No prior pelvic surgery	1.00	
≥ 1 prior pelvic surgery	1.01 [0.58, 1.78]	
Non-gynecological prior abdominal surgeries		
No prior abdominal surgery	1.00	1.00
≥ 1 prior abdominal surgery	**2.06 [1.16, 3.67]**	**2.01 [1.05; 3.83]**
Surgeon factors		
Surgeon volume† (OR days per month)		
Low (<1)	1.00	1.00
Medium(1 - 2)	0.41 [0.16; 1.02]	**0.30 [0.10; 0.87]**
High(>2)	0.93 [0.42; 2.07]	1.35 [0.51; 3.56]
Peri-operative factors		
Admission type		
Planned	1.00	1.00
Emergency	**3.19 [1.06, 9.59]**	**19.54 [2.99; 127.54]**
Approach of surgery		
Vaginal approach	1.00	1.00
Laparoscopy	0.78 [0.36, 1.68]	1.58 [0.64; 3.90]
Laparotomy	**3.69 [1.76, 7.74]**	2.75 [0.89; 8.45]

	Intra or post operative complications	
	Univariate logistic models	Multivariable logistic model
Variables	**OR [95% CI]**	**OR [95% CI]**
Conversion to laparotomy	**8.93 [3.25, 24.53]**	2.75 [0.75; 10.10]
Operative time ≥ 180 minutes	1.44 [0.72, 2.86]	
Pre-operative hemoglobin ≥ 120 g/L	1.75 [0.93, 3.30]	
Peri-operative prophylactic antibiotics when recommended		
Recommended, received	1.00	1.00
Recommended, not received	1.56 [0.73, 3.34]	2.09 [0.85; 5.10]
Not recommended	**0.08 [0.02, 0.35]**	**0.08 [0.01; 0.45]**
Thromboprophylaxis		
Received	1.00	1.00
Not received	0.38 [0.21, 0.69]	0.46 [0.21; 1.01]
Complexity (endo 3-4, fibroids 500g+, cyst 10+)		
No	1.00	1.00
Yes	**2.98 [1.60; 5.52]**	2.20 [0.91; 5.32]
Main diagnosis and severity		
Other	1.00	
Fibroids	1.36 [0.65, 2.84]	
Endometriosis	0.79 [0.21, 2.93]	
Prolapse	0.58 [0.24, 1.40]	
Ovarian cyst	0.47 [0.14, 1.50]	
Stress Incontinence	na	
Family planning	na	

OR=Odds Ratio; ORs are in Bold font are significant
*BMI: Body Mass Index †Surgeon volume was treated as a random effect

TABLE 4 Univariate and Multivariable Analysis of Risk Factors and their Impact on Complication Rates (n=975)

REFERENCES

1. Margulies SL, Vargas MV, Denny K, Sparks AD, Marfori CQ, Moawad G, et al. Comparing benign laparoscopic and abdominal hysterectomy outcomes by time. Surgical Endoscopy. 2020;34(2):758-69.doi: 10.1007/s00464-019-06825-8.

2. Clarke-Pearson DL, Geller EJ. Complications of hysterectomy. Obstet Gynecol. 2013;121(3):654-73.doi: 10.1097/AOG.0b013e3182841594.

3. Rademaker D, Einarsson JI, Huirne JAF, Gu X, Cohen SL. Vaginal or laparoscopic hysterectomy: Do perioperative outcomes differ? A propensity score-matched analysis. Acta Obstetricia et Gynecologica Scandinavica. 2019;98(8):1040-5.doi: 10.1111/aogs.13591.

4. Alammari RA, Jorgensen EM, Modest AM, Chu J, King LP, Awtrey CS. Impact of prior hysterectomy on surgical outcomes for laparoscopic adnexal surgery. Surgical Endoscopy. 2019.doi: 10.1007/s00464-019-07083-4.
5. Barouhas I, Mouhayar Y, Stephan J-M. Intraoperative Bowel Injury During Hysterectomy. Journal of Gynecologic Surgery. 2021;37(3):197-9.doi: 10.1089/gyn.2020.0230.
6. Brady PC. Complications of Minimally Invasive Gynecologic Surgery 2016. In: Handbook of Consult and Inpatient Gynecology [Internet]. Springer International Publishing. 1st edition. [p.419-64].
7. Khalife T, Fatchikov T, Anil G. Intraoperative Genitourinary Injuries During a Hysterectomy: Risks, Management, and Mitigation Strategies. Journal of Gynecologic Surgery. 2021;37(3):190-6.doi: 10.1089/gyn.2021.0041.
8. Mehta A, Xu T, Hutfless S, Makary MA, Sinno AK, Tanner EJ, 3rd, et al. Patient, surgeon, and hospital disparities associated with benign hysterectomy approach and perioperative complications. Am J Obstet Gynecol. 2017;216(5):497.e1-.e10.doi: 10.1016/j.ajog.2016.12.020.
9. Worley MJ, Jr., Anwandter C, Sun CC, dos Reis R, Nick AM, Frumovitz M, et al. Impact of surgeon volume on patient safety in laparoscopic gynecologic surgery. Gynecol Oncol. 2012;125(1):241-4.doi: 10.1016/j.ygyno.2011.12.452.
10. Bütter A, Merritt N, Dave S. Establishing a pediatric robotic surgery program in Canada. J Robot Surg. 2017;11(2):207-10.doi: 10.1007/s11701-016-0646-0.
11. Spitz S. Canada lags in using robotic surgery. Cmaj. 2013;185(8):E305-6.doi: 10.1503/cmaj.109-4429.
12. MD+CALC. Charlson Comorbidity Index (CCI) [Available from: https://www.mdcalc.com/charlson-comorbidity-index-cci.
13. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: executive summary. Expert Panel on the Identification, Evaluation, and Treatment of Overweight in Adults. The American Journal of Clinical Nutrition. 1998;68(4):899-917.doi: 10.1093/ajcn/68.4.899.
14. Mahdi H, Goodrich S, Lockhart D, DeBernardo R, Moslemi-Kebria M. Predictors of surgical site infection in women undergoing hysterectomy for benign gynecologic disease: a multicenter analysis using the national surgical quality improvement program data. J Minim Invasive Gynecol. 2014;21(5):901-9.doi: 10.1016/j.jmig.2014.04.003.
15. World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity 2011 [Available from: https://www.who.int/vmnis/indicators/haemoglobin/en/.
16. Sinha R, Sundaram M, Lakhotia S, Mahajan C, Manaktala G, Shah P. Total laparoscopic hysterectomy for large uterus. J Gynecol Endosc Surg. 2009;1(1):34-9.doi: 10.4103/0974-1216.51908.
17. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240(2):205-13.doi: 10.1097/01.sla.0000133083.54934.ae.
18. Erekson EA, Yip SO, Ciarleglio MM, Fried TR. Postoperative complications after gynecologic surgery. Obstet Gynecol. 2011;118(4):785-93.doi: 10.1097/AOG.0b013e31822dac5d.
19. Debeche-Adams TH, Bohl JL. Rectovaginal fistulas. Clin Colon Rectal Surg. 2010;23(2):99-103.doi: 10.1055/s-0030-1254296.
20. Chen CC, Collins SA, Rodgers AK, Paraiso MF, Walters MD, Barber MD. Perioperative complications in obese women vs normal-weight women who undergo vaginal surgery. Am J Obstet Gynecol. 2007;197(1):98.e1-8.doi: 10.1016/j.ajog.2007.03.055.
21. Esparaz AM, Pearl JA, Herts BR, LeBlanc J, Kapoor B. Iatrogenic urinary tract injuries: etiology, diagnosis, and management. Semin Intervent Radiol. 2015;32(2):195-208.doi: 10.1055/s-0035-1549378.
22. Stamatakos M, Sargedi C, Stasinou T, Kontzoglou K. Vesicovaginal fistula: diagnosis and management. Indian J Surg. 2014;76(2):131-6.doi: 10.1007/s12262-012-0787-y.
23. Hosmer DWJLSS, Rodney X. . Applied Logistic Regression. 3rd edition ed: New York: John Wiley Sons; 2013. 528 p.
24. Schwarz G. Estimating the Dimension of a Model. The Annals of Statistics. 1978;6(2):461-4.
25. Fitzmaurice GML, Nan M. ; Ware, James H. . Applied Longitudinal Analysis. 2 ed. Hoboken, NJ: John Wiley Sons Inc.; 2011. 752 p.
26. Snijders TAB, Bosker RJ. Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling: SAGE Publications; 2011.
27. Havens JM, Peetz AB, Do WS, Cooper Z, Kelly E, Askari R, et al. The excess morbidity and mortality of emergency general surgery. J Trauma Acute Care Surg. 2015;78(2):306-11.doi: 10.1097/ta.0000000000000517.
28. Mullen MG, Michaels AD, Mehaffey JH, Guidry CA, Turrentine FE, Hedrick TL, et al. Risk Associated With Complications and Mortality After Urgent Surgery vs Elective and Emergency Surgery: Implications for Defining "Quality" and Reporting Outcomes for Urgent Surgery. JAMA Surgery. 2017;152(8):768-74.doi: 10.1001/jamasurg.2017.0918.
29. Bai SW, Huh EH, Jung DJ, Park JH, Rha KH, Kim SK, et al. Urinary tract injuries during pelvic surgery: incidence rates and predisposing factors. Int Urogynecol J Pelvic Floor Dysfunct. 2006;17(4):360-4.doi: 10.1007/s00192-005-0015-4.
30. Kaya AC, Radosa MP, Zimmermann JSM, Stotz L, Findeklee S, Hamza A, et al. Intraoperative and postoperative complications of gynecological laparoscopic interventions: incidence and risk factors. Archives of Gynecology and Obstetrics. 2021;304(5):1259-69.doi: 10.1007/s00404-021-06192-7.

31. Crowe S, Sharma S. A practical guide to quality improvement. The Obstetrician Gynaecologist. 2017;19(1):71-6.doi: 10.1111/tog.12354.
32. Pakbaz M, Rolfsman E, Löfgren M. Are women adequately informed before gynaecological surgery? BMC Womens Health. 2017;17(1):68-.doi: 10.1186/s12905-017-0426-7.
33. Chowdhury MM, Dagash H, Pierro A. A systematic review of the impact of volume of surgery and specialization on patient outcome. BJS (British Journal of Surgery). 2007;94(2):145-61.doi: 10.1002/bjs.5714.
34. Clark NV, Gujral HS, Wright KN. Impact of a Fellowship-Trained Minimally Invasive Gynecologic Surgeon on Patient Outcomes. JSLS. 2017;21(3):e2017.00037.doi: 10.4293/JSLS.2017.00037.
35. Malacarne DR, Boyd LR, Long Y, Blank SV. Best practices in risk reducing bilateral salpingo-oophorectomy: the influence of surgical specialty. World J Surg Oncol. 2017;15(1):218.doi: 10.1186/s12957-017-1282-5.
36. Rayburn WF, Gant NF, Gilstrap LC, Elwell EC, Williams SB. Pursuit of accredited subspecialties by graduating residents in obstetrics and gynecology, 2000-2012. Obstet Gynecol. 2012;120(3):619-25.doi: 10.1097/AOG.0b013e318265ab0a.
37. Igwe E, Hernandez E, Rose S, Uppal S. Resident participation in laparoscopic hysterectomy: impact of trainee involvement on operative times and surgical outcomes. Am J Obstet Gynecol. 2014;211(5):484.e1-7.doi: 10.1016/j.ajog.2014.06.024.
38. Lateef F. Simulation-based learning: Just like the real thing. J Emerg Trauma Shock. 2010;3(4):348-52.doi: 10.4103/0974-2700.70743.
39. Garber A, Posner G, El-Chaar D, Mitchell T. Simulation-Based Education in Obstetrics and Gynaecology Training in Canada. Journal of Obstetrics and Gynaecology Canada. 2013;35(11):975-6.doi: 10.1016/S1701-2163(15)30782-9.
40. Lethaby A, Puscasiu L, Vollenhoven B. Preoperative medical therapy before surgery for uterine fibroids. Cochrane Database of Systematic Reviews. 2017(11).doi: 10.1002/14651858.CD000547.pub2.
41. Munting KE, Klein AA. Optimisation of pre-operative anaemia in patients before elective major surgery - why, who, when and how? Anaesthesia. 2019;74 Suppl 1:49-57.doi: 10.1111/anae.14466.