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ORIGINAL RESEARCH & CONTRIBUTIONS

Safely Increase the Minimally Invasive Hysterectomy Rate: A Novel Three-Tiered Preoperative Categorization System Can Predict the Difficulty for Benign Disease

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ABSTRACT

Context: A nonlaparotomic route is recommended for hysterectomy for benign indications.

Objective: 1) Predict the difficulty of hysterectomy to treat benign disease as measured by operative time and risk of laparotomy, 2) confirm the safety and quality of increasing our minimally invasive hysterectomy (MIH) rate, and 3) determine whether the assistant's experience affected the likelihood of an MIH being performed in equally difficult hysterectomies.

Design: All hysterectomies for benign disease performed at the Kaiser Permanente Fontana Medical Center in Fontana, CA, in 2012 were reviewed for length of surgery, length of stay, complications, and readmissions. A three-tiered category system was developed from four preoperative parameters (body mass index, number of vaginal deliveries, clinical uterine size, and history of major abdominal surgery) to anticipate length and difficulty of surgery.

Main Outcome Measures: Rates of MIH, complications, and readmissions as well as length of surgery and length of stay for similarly difficult hysterectomies. These outcomes were compared with surgeons' and assistants' experience.

Results: Of 576 hysterectomies performed for benign disease, 89% were MIH with a 3% complication rate and 4% readmission rate. An increase in the hysterectomy category was statistically significantly associated with longer surgery times and a higher percentage of laparotomy. With the most experienced assistants, the MIH rate was 98%.

Conclusions: Using 4 preoperative parameters, the average operating time for hysterectomy for benign disease can be predicted. A higher hysterectomy category predicts a more difficult surgery. Our center has increased its MIH rate to 89% while maintaining safety.

INTRODUCTION

Approximately 600,000 hysterectomies are performed annually in the US.[1] In 1998, approximately 65% of hysterectomies were performed via laparotomy, and in 2010, this rate went down to 54.2%.[2] Both the American College of Obstetricians and Gynecologists[3] and Advancing Minimally Invasive Gynecology Worldwide[4] have recommended a minimally invasive route (nonlaparotomic) for hysterectomy for benign disease. Andryjowicz and Wray[5] demonstrated how the Southern California Permanente Medical Group reached a 78% rate of minimally invasive hysterectomy (MIH), across 13 Medical Centers involving more than 350 general gynecologists performing 4000 hysterectomies yearly for benign indications. This was achieved with education and expert mentoring. With a continued increase in MIH at our Medical Center, we wanted to ensure that safety and quality were maintained. It is more important than ever to be excellent stewards of our health care resources in this time of emphasis on value in health care.

The ability to determine how difficult a hysterectomy will be and to estimate the time required to perform it would enable a gynecologic practice to enhance surgeon and assistant pairing and operating room (OR) utilization as well as recognize the increased skills needed for the more difficult surgeries. Time in the OR is an expensive commodity, estimated to be more than $30 a minute at our Medical Center. Underbooking or overbooking cases is costly to the system in both dollars and stress on staffing. It also inconveniences patients waiting longer for elective surgeries if ORs are underutilized.

From a review of surgical case times at our Medical Center, across multiple specialties, we believed we could reduce the time between the closing incision at the end of one case to the start of the next case incision to 65 minutes for hysterectomies for benign disease. We chose this metric over the well-known "out of room to into room" because it better describes what the surgeon sees as the total nonoperating time in an OR. In our all-day surgical block, the first case was to be on the OR table by 7:15 am with a time for the surgeon's incision by 7:55 am, and the last case was expected to be closed by 5 pm. This allowed 545 minutes of total OR time for the day, which would include the nonoperating close to incision time of 65 minutes between cases.

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Several factors have been shown individually to affect the difficulty of performing a hysterectomy for benign disease. We combined four of these factors to preoperatively predict the length and difficulty of surgery.

A lack of history of vaginal delivery has been shown to increase the length of the surgical procedure, although it may or may not increase the complication rate, and it does not change the length of stay (LOS) or the readmission rates.[6-9] An increasing uterine size also has been shown to increase the operative time, complication rates, and surgical conversions from MIH to laparotomy.[10-15] With increasing body mass index (BMI), there is an increase in length of surgery, but no major increased risk of conversion from an MIH to laparotomy or of LOS, complications, or readmissions.[16-24] A history of laparotomies increases the risk of conversion from vaginal hysterectomy to laparotomy, which can increase the length of surgery[25] and the number of complications.[15,26,27] Surgeon experience and volume of surgery can affect operating time, complication rates, risk of conversion from MIH to laparotomy, LOS, costs, and surgical approach taken for hysterectomy for benign disease.[26,28-34]

The more experienced gynecologists at our Medical Center are able to predict the difficulty, and therefore the length of time required to perform a hysterectomy for benign disease, although this skill is not universal. They frequently arrange for an experienced assistant when difficult surgery is anticipated, again not universally. We sought to develop a method to help all our gynecologists identify the more challenging cases so that they could both book longer OR time and arrange a more experienced assistant to improve their MIH rates while maintaining safety. Additionally, if all the cases for the day were anticipated to be of shorter duration, an extra case could be booked to improve efficiency.

The aims of this study were

1. to predict the difficulty of hysterectomy for benign disease, measured by operative time and risk of laparotomy
2. to confirm the safety and quality of increasing the MIH rate by comparing complication and readmission rates with the literature
3. to determine if the assistant's experience affected the likelihood of an MIH.

METHODS

This study was approved by the Kaiser Permanente Southern California (KPSC) institutional review board and was carried out at Kaiser Permanente Fontana Medical Center in Fontana, CA, 1 of 14 KPSC Medical Centers. In 2012, Fontana Medical Center provided services to approximately 430,000 patients. There were 39 general obstetrician-gynecologists performing hysterectomies for benign disease. We arbitrarily labeled the 19 clinicians having less than 3 years of consultant experience as junior. The 2 clinicians with extensive MIH experience were labeled senior, and the 18 clinicians with experience between these 2 levels were labeled midlevel. In 55 cases a resident physician from Loma Linda University was the primary assistant.

For type of hysterectomy performed, standard definition was used for total abdominal hysterectomy. Hysterectomy included the following:

- Laparoscopic-assisted vaginal hysterectomy: most cases included uterine artery coagulation via laparoscopy
- Vaginal hysterectomy
- Total laparoscopic hysterectomy: most removed vaginally
- Minilaparotomy: a 4- to 5-cm or smaller incision for removal of the specimen
- No robotic-assisted hysterectomies were carried out during the study period.

Minilaparotomy was classified as an MIH-type procedure. It has been shown that minilaparotomy for hysterectomy is better than laparotomy but not as good as the laparoscopic approach as related to morbidity and LOS.[35-37] In our 21 cases with minilaparotomy for removal of the specimen, 19 patients went home by morning, and the highest pain score during their stay was less than 5 of 10 on a visual analog scale, with morbidity similar to any other MIH procedure.

All hysterectomies for benign disease performed in 2012 were identified from discharge codes (International Classification of Diseases, Ninth Revision): 68.41, 68.49, 68.51, and 68.59. These electronic medical records were then individually reviewed by the authors (each author reviewed about 120 charts) to remove all oncology cases, as well as any cases with add-on procedures planned other than cystoscopy. Outcome measures reviewed included length of surgery in minutes (incision to close), LOS in hours (out of room to out of hospital), complications, and readmissions before the 4-week postoperative visit. Other parameters reviewed included surgeon-assistant pairing as well as the patient's BMI, medical history, surgical history, obstetric history, estimated uterine size, and actual uterine weight. Operative notes, discharge summaries, and notes from the first postoperative office visit were reviewed as well as the notes section in the electronic medical record to look for any other admission and discharge summaries after the initial surgical date. Follow-up was from 3 to 14 months postoperatively at the time of data collection.

We categorized hysterectomy for benign disease into Category 1, 2, or 3 depending on 4 preoperative parameters: 1) clinical uterine size (equivalence by weeks of gestation, a common gynecologic descriptive to indicate the size of a nonpregnant uterus), 2) BMI, 3) number and type of previous major abdominal surgeries (defined as cesarean delivery; hernia repair; appendectomy; myomectomy; bariatric; bowel; or endometriosis surgery), and 4) number of vaginal deliveries.

Table 1 demonstrates how the categories were defined and how many hysterectomies were in each category. Category 1 included a uterine size equivalent to or less than 12 weeks' gestation, a BMI less than 30 kg/m^2, up to 1 previous laparotomy, and at least 1 vaginal delivery. Category 2 included 1 or 2 of the following factors: clinical uterine size of greater than 12 weeks but less than 18 weeks, a BMI of 30 to 40 kg/m^2, 2 or 3 prior major abdominal surgeries, and no prior vaginal deliveries. If there were 3 Category 2 items, the patient moved up to Category 3. Category 3 also included those with any one of the

Table 1. Patient characteristics of the categories of hysterectomy (N = 576)

Category	Measure
Category 1: *All* of below items (n = 140)	
BMI, kg/m^2	< 30
Major abdominal surgery, no.	≤ 1
Clinical uterine size, weeks	≤ 12
Vaginal delivery, no.	≥ 1
Category 2: 1 or 2 of below items (n = 279)	
BMI, kg/m^2	30-40
Major abdominal surgery, no.	2-3
Clinical uterine size, weeks	>12 - <18
Vaginal delivery, no.	0
Category 3: *Any* of below items (n = 157)	
BMI, kg/m^2	> 40
Major abdominal surgery, no.	> 3
Clinical uterine size, weeks	≥ 18
Total Category 2 items	3 or 4

BMI = body mass index; n = number of hysterectomies performed in each category.

following: a clinical uterine size 18 weeks or greater, BMI greater than 40 kg/m^2, or 4 or more prior major abdominal surgeries.

All surgeons were encouraged to categorize their hysterectomies preoperatively and to be proactive in obtaining an assistant with the appropriate level of experience. The OR schedulers were also encouraged to use categorization and their knowledge of the surgeons and assistants to notify the Chief of the Department (TBW) when there seemed to be a mismatch between difficulty of surgery and surgeon-assistant pairing. When a mismatch was identified, a gynecologist more experienced in MIH was moved in to assist. However, this did not occur in all cases because of scheduling conflicts or simple oversight. The entire group was aware of the availability of the senior clinicians for the most difficult cases. In our center, the surgeon and assistant each tend to perform about half of the surgery (ie, their side of the hysterectomy). Educational rounds and expert mentoring were the primary methods used to improve our MIH rates safely.

Patient characteristics were described using percentages or the mean and standard deviation (SD). Statistical analysis to assess differences among patient characteristics and surgical measures between procedure types or categories was performed using the Kruskal-Wallis test for continuous measures and the χ^2 test for categorical factors. The number and percentage of MIH surgeries by combination of surgeon and assistant were tabulated. Multivariate linear regression was used to assess the association of preoperative factors with length of surgery. Logistic regression was used to assess the likelihood of MIH by surgeon and assistant. As senior surgeons performed only MIH in 2012, they were excluded from the model. Logistic regression was also used to assess the likelihood of MIH by surgeon and assistant when adjusting for surgical category and in the subset of Category 3 surgeries. Statistical analysis was performed using SAS 9.2 (SAS, Cary, NC). All tests were 2-sided, and p values of less than 0.05 were taken to indicate statistical significance.

RESULTS

There were 576 hysterectomies for benign disease carried out at the Fontana Medical Center in 2012, with an overall 89% MIH rate. Table 2 shows the number of each type of MIH.

Figure 1 shows the association of category with type of hysterectomy performed. As the category increased, the percentage of MIH decreased from 98% in Category 1 to 91% in Category 2 to 77% in Category 3. The odds ratio to perform MIH for Category 2 vs 1 was 0.21 (confidence interval = 0.06-0.70) and for Category 3 vs 1 was 0.06 (confidence interval = 0.02-0.20), both significantly reduced.

Table 3 reviews the type, number, and percentages of complications and readmissions, with a total rate of 4% complications and 3% readmissions. One ureteric injury was identified 1 week postoperatively and was repaired 2 months later, with no long-term sequelae.

Table 2 compares the various types of hysterectomy performed. It demonstrates that there were significant differences between the type of hysterectomy performed and uterine weight, previous major abdominal surgery and vaginal delivery, with no significant difference related to BMI. There

Table 2. Comparison factor by type of hysterectomy (N = 576)

Factor	LAVH (n = 409)	VH (n = 68)	TLH (n = 14)	Minilaparotomy (n = 21)	TAH (n = 44)	TAH from conversion (n = 20)	p value
Mean BMI, kg/m^2 (SD)	31 (7)	30 (7)	32 (9)	32 (8)	32 (7)	33 (6)	0.51
Mean uterine weight, g (SD)	241 (203)	157 (89)	220 (158)	1112 (620)	755 (916)	843 (1421)	<0 .0001[a]
Previous major abdominal surgery, no. (%)	202 (49)	13 (19)	10 (71)	9 (43)	23 (52)	13 (61)	< 0.0002[a]
Vaginal delivery, no. (%)	294 (72)	67 (98)	5 (36)	6 (29)	19 (43)	9 (39)	< 0.0001[a]
Mean incision-close, minutes (SD)	121 (48)	70 (25)	156 (62)	229 (63)	121 (40)	192 (75)	< 0.0001[a]
Mean length of stay, hours (SD)	19 (12)	24 (10)	27 (20)	24 (10)	67 (27)	64 (38)	< 0.0001[a]
Complication, no. (%)	11 (2)	3 (4)	1 (7)	0 (0)	2 (4)	7 (35)	< 0.0001[a]
Readmission, no. (%)	11 (2)	3 (4)	0 (0)	1 (5)	2 (4)	0 (0)	0.999

[a] Statistically significant at p < 0.05.

BMI = body mass index; LAVH = laparoscopic-assisted vaginal hysterectomy; SD = standard deviation; TAH = total abdominal hysterectomy; TLH = total laparoscopic hysterectomy; VH = vaginal hysterectomy.

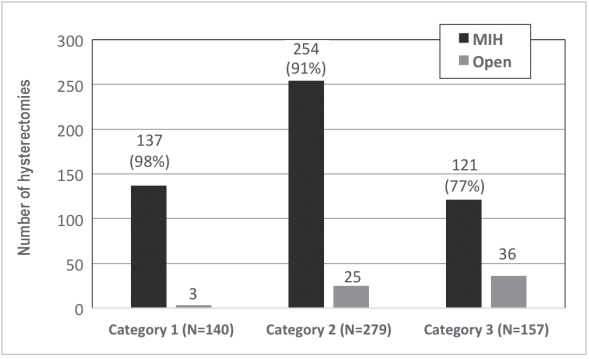

Figure 1. Number and percentages of minimally invasive hysterectomies (MIH) and open hysterectomies versus category of hysterectomy (N = 576).

were also statistically significant differences in length of surgery, LOS, and complication rate but not in readmission rate. The largest uterus for MIH weighed 2482 g and for laparotomy 6071 g. The largest BMI for a patient undergoing MIH was 57 kg/m^2 and for laparotomy was 52 kg/m^2. The highest number of previous laparotomies for a patient undergoing MIH was 6, and for laparotomy it was 4. Of the 20 conversions to laparotomy, 18 originated as laparoscopic-assisted vaginal hysterectomy (4.4% of all laparoscopic-assisted vaginal hysterectomies performed) and 2 originated as vaginal hysterectomy (2.9% of all vaginal hysterectomies).

Table 4 compares the categories of hysterectomy. As expected from the criteria used to categorize, Category 1 had the smallest uteri, lightest patients, lowest percentage of previous major abdominal surgeries, and the highest percentage of previous vaginal deliveries. Category 3 was at the other end of the spectrum, and Category 2 was in-between. All these were statistically significant differences (Table 4). There were also statistically significant differences found in length of surgery and LOS, but not in complication or readmission rates.

Category 1 hysterectomies lasted approximately 1.5 hours; Category 2, approximately 2 hours; and Category 3, approximately 2.5 hours. The mean LOS increased from 20 (SD = 19) hours for Category 1 to 23 (SD = 18) hours for Category 2 and to 32 (SD = 25) hours for Category 3 ($p < 0.0001$). However, if one looks at the MIH procedures only, the increase in LOS was much smaller, from 18 (SD = 10) hours for Category 1 to 19 (SD = 12) hours for Category 2 and 23 (SD = 14) hours for Category 3, and did not reach statistical significance ($p = 0.088$). Category 3 simply had a larger percentage of open cases (23%) with their expected longer LOS.

Senior surgeons performed only MIH during the year (meaning no planned laparotomies or surgical conversions in 2012), whereas for midlevel and junior surgeons, 88% of the hysterectomies they performed were MIH. Table 5 reviews the rates of MIH depending on surgeon and assistant experience. For both junior and midlevel surgeons, their rates of MIH were below 85% when paired with a junior assistant and above 95% when paired with a senior assistant, with rates in-between for midlevel assistants. The likelihood of MIH based on the combination of surgeon and assistant is shown in Table 6. The effect of the surgeon's experience between junior and midlevel was not significant. Also, there was no difference when a junior or resident was assisting. However, both junior and midlevel surgeons were somewhat more likely to perform MIH if paired with a midlevel assistant and greatly more likely to perform MIH if paired with a senior assistant, compared with a junior assistant.

Table 7 shows the impact of surgeon-assistant pairing on likelihood of MIH accounting for the category (difficulty) of the surgery. Although higher categories were associated with a significantly lower odds of MIH, more experienced assistants were still associated with a significantly greater likelihood of MIH. In the Category 3 hysterectomies (most complex and least likely to be performed in a minimally invasive fashion), only the surgeries with senior assistants were significantly more likely to be performed as an MIH compared with those procedures with junior assistants.

DISCUSSION

Using categorization, we find that we can accurately predict difficulty of hysterectomy for benign disease, and thus accurately determine allocation of OR time and the need for assistance from an experienced surgeon with excellent MIH rates. In addition, we confirm the safety, quality, and efficiency of our 89% MIH rate with a complication and readmission rate of 4% and 3% respectively, consistent with rates from a recent review.[38]

Importantly, categorization of hysterectomy allows for more accurate research comparisons. We can now look to

Table 3. Complications and readmissions of hysterectomy for benign disease (N = 576)

Complication type	No. (%)
Bladder injury	9 (1.6)
Transfusion	8 (1.4)
Repeat surgery same admission	4 (0.7)
Ureter injury (1 week postoperative)	1 (0.2)
Ileus needing hospitalization	1 (0.2)
Bowel injury	0 (0)
Total	23 (4.0)
Readmission reason	
Vaginal vault bleeding	1 (0.2)
Abscess	3 (0.5)
Hematoma	1 (0.2)
Fever	1 (0.2)
Wound infection	2 (0.3)
Bowel obstruction	2 (0.3)
Ureter repair	1 (0.2)
Pain	1 (0.2)
Pulmonary embolism	1 (0.2)
Cardiac disease	1 (0.2)
Urine retention with renal failure	1 (0.2)
Abscess, fever, and hematoma	1 (0.2)
Abscess, fever, IR drain, vesicovaginal fistula, and vaginal repair 2 months later	1 (0.2)
Total	17 (3.0)

IR = placed by Interventional Radiology.

find the best MIH procedure for length of surgery, short-term and long-term morbidity, LOS, readmissions, total costs, return-to-work timing, and patient satisfaction. We can also investigate the surgeon's and assistant's contribution to these outcomes. At some point, this method could also be used for determining relative value unit decisions related to hysterectomies for benign disease, recognizing the increased effort required to perform more complex surgeries. We as surgeons are the stewards of a major component of health care costs, and it is imperative that we maximize our value at the same time as we improve our surgical outcomes.

By using 4 preoperative parameters, the approximate surgical time for a hysterectomy for benign disease can be predicted. Identification of more difficult cases (Category 3) has allowed a proactive scheduling of cases with more experienced MIH assistants in most, but not all, cases. In our center of 39 general gynecologists, with 49% having less than 3 years of consultant experience, 576 hysterectomies were performed for benign indications, with an 89% MIH rate. With increasing category, there was a significant decrease in MIH overall.

These parameters were chosen because they were obtainable preoperatively and had individually been shown in the literature to affect surgical time and possibly LOS, complications, or readmissions. A review of these parameters follows with data related to any effects on hysterectomy.

Vaginal Delivery History

The medical literature was reviewed for studies that evaluated the effect of nulliparity or lack of vaginal delivery on hysterectomy and outcomes. Although most hysterectomy studies use parity as one of several case-control factors, very few directly compared nulliparous with parous outcomes. Most of the nulliparous patient studies were designed to refute the long-held belief that vaginal hysterectomy is contraindicated when there is no history of vaginal delivery. This has been done with great success and is well documented in the literature.[9] Two studies have identified an increased length of surgery in the nulliparous patient compared with the parous patient.[6,7] There was no difference in LOS postoperatively between nulliparous and parous patients having similar procedures.[7] Regarding complications in nulliparous vs parous patients at hysterectomy, there are mixed reports in the literature. Two studies reported higher complication rates in the nullipara,[6,7] and one study reported no difference in complication rates between nulliparous and parous patients.[8] One study showed no difference in hospital readmission rates between nulliparous and parous patients after laparoscopic-assisted vaginal hysterectomy.[6]

Uterine Size

Laparoscopic hysterectomy can be performed safely even in the presence of a large uterus,[10] yet studies have reported complications such as bladder injury and ureteric injury directly related to uterine size.[11] Some surgeons set an upper limit to uterine size when considering a laparoscopic approach to hysterectomy, of usually 15 to 16 weeks' gestation or a weight of 500 g because of higher risk of bowel and urinary tract injury as well as hemorrhage.[12]

Table 4. Comparison factor by category of hysterectomy (N = 576)

Factor	Category 1 (n = 140)	Category 2 (n = 279)	Category 3 (n = 157)	p value
Mean BMI, kg/m^2 (SD)	26 (3)	31 (5)	36 (8)	< 0.0001[a]
Mean uterine weight, g (SD)	162 (94)	250 (208)	586 (790)	< 0.0001[a]
Previous major abdominal surgery, no. (% of category)	32 (23)	139 (50)	99 (63)	< 0.0001[a]
Vaginal delivery, no. (% of category)	140 (100)	199 (71)	62 (39)	< 0.0001[a]
Mean incision to close, minutes (SD)	96 (43)	122 (54)	146 (61)	< 0.0001[a]
Mean length of stay, hours (SD)	20 (19)	23 (18)	32 (25)	< 0.0001[a]
Complication, no. (% of category)	5 (4)	8 (3)	7 (4)	0.768
Readmission, no. (% of category)	4 (3)	7 (3)	6 (4)	0.656

[a] Statistically significant at $p < 0.05$.
BMI = body mass index; SD = standard deviation.

Table 5. Surgeon-assistant pairing[a] and likelihood of MIH

Surgeon (N = 576)	Assistant	No MIH, no. (%)	MIH, no. (%)
Junior (n = 250)	Resident	1 (7)	13 (93)
	Junior	10 (18)	45 (82)
	Midlevel	18 (13)	123 (87)
	Senior	1 (3)	39 (97)
Midlevel (n = 284)	Resident	5 (14)	30 (86)
	Junior	19 (17)	90 (83)
	Midlevel	9 (9)	9 (91)
	Senior	1 (3)	35 (97)
Senior (n = 42)	Resident	0 (0)	6 (100)
	Junior	0 (0)	15 (100)
	Midlevel	0 (0)	13 (100)
	Senior	0 (0)	8 (100)

[a] See "Methods" section in the text for an explanation of levels of provider experience.
MIH = minimally invasive hysterectomy.

An increase in operative time and greater estimated blood loss have been observed to parallel increasing uterine size.[13] With greater estimated blood loss, there is also a greater risk of blood transfusion associated with increasing uterine weight. This is true for both abdominal and laparoscopic hysterectomy.[14] Also, an increase in the conversion rate from a laparoscopic approach to an open surgical procedure has been reported with larger uteri.[15]

Body Mass Index

Studies show an increased operative time with larger BMI.[16,20,22-24] Another study showed no statistical difference in the length of surgery in obese patients compared with nonobese patients,[17] but difficult cases were performed by a senior attending physician as opposed to a junior attending or resident. Another study showed no difference in operating time with higher BMI during robotic hysterectomies.[18]

There was no change in LOS[17,20,23] in obese patients, including during robotic hysterectomies.[18] However, there was an increased LOS in obese women undergoing abdominal hysterectomies.[22]

There was no change in the complication rate depending on BMI[16,17,19,22] except for one study indicating an increased

Table 6. Likelihood of minimally invasive hysterectomy depending on surgeon and assistant

Surgeon-assistant pairing	Odds ratio (95% CI)	p value
Surgeon midlevel vs junior	1.17 (0.67-2.02)	0.5816
Assistant resident vs junior	1.53 (0.59-3.93)	0.3789
Assistant midlevel vs junior	1.80 (1.01-3.22)[a]	0.0478[a]
Assistant senior vs junior	8.19 (1.89-35.5)[a]	0.0049[a]

[a] Statistically significant at $p < 0.05$.
CI = confidence interval.

severity of complications with greater BMI.[20,23] There was no increased obesity-related risk of conversion to open surgery from laparoscopic[17] or robotic hysterectomies.[18] There was an increased risk of conversion to laparotomy in a study performed by Shen et al,[19] but there were low numbers of obese women in this study. There also were no changes in readmission rates in obese patients.[16]

The primary strength of this article is that the authors reviewed all 576 hysterectomies for benign disease performed by 39 general gynecologists during an entire year.

Previous Abdominal Surgery

One study revealed longer operative time in surgeries converted from vaginal hysterectomy to laparotomy; the most frequent reason for conversion was dense adhesions, so previous abdominal surgery increased the risk of conversion.[25]

Three studies indicated that the number of previous abdominal surgeries increased the risk of complications,[15,26,27] two of which specifically mentioned previous cesarean deliveries and bladder injury.

Surgeon Experience and Surgical Volume

A surgeon's experience and/or volume of surgical cases has been a very difficult area to quantitate, yet can affect the outcomes of hysterectomy. One of many confounding variables is that high-volume surgeons tend to perform more complicated cases and be involved in teaching, which may be a factor in some studies that do not show a correlation with surgical times. On review, three studies showed a decrease in OR times for high-volume surgeons,[28,31,32] whereas one study showed no significant difference.[26] For complications, three studies have shown a reduction in high-volume surgeons,[29-31] whereas three other studies showed no difference[28,32,39] and one showed a significant decrease over time reflective of volume and experience.[33] There was no difference in conversions between high- and low-volume surgeons, but among high-volume surgeons decreased conversions occurred over time.[32] A minimally invasive surgical approach was offered more often by high-volume surgeons.[30,34] Also, the cost for delivery of surgery was lower for high-volume surgeons,[29,31] and the hospital LOS was reduced for high-volume surgeons.[30-32]

Table 7. Likelihood of minimally invasive hysterectomy depending on category

Surgeon-assistant pairing	Odds ratio (95% CI)	p value
Surgeon midlevel vs junior, all categories	1.35 (0.75-2.41)	0.3180
Assistant resident vs junior, all categories	1.48 (0.55-4.01)	0.4361
Assistant midlevel vs junior, all categories	2.26 (1.21-4.20)[a]	0.0102[a]
Assistant senior vs junior, all categories	13.2 (2.93-59.1)[a]	0.0008[a]
Surgeon midlevel vs junior, Category 3	1.88 (0.79-4.48)	0.1544
Assistant resident vs junior, Category 3	0.85 (0.18-4.15)	0.8434
Assistant midlevel vs junior, Category 3	2.20 (0.88-5.54)	0.0939
Assistant senior vs junior, Category 3	9.97 (1.91-52.0)[a]	0.0063[a]

Bold highlights surgeon comparison vs other comparisons, which relate to assistants.
[a] Statistically significant at $p < 0.05$.
CI = confidence interval.

Even though there were efforts to ensure that all Category 3 cases would have at least 1 member of the surgeon-assistant team be more experienced, we found that in 13% of these cases a junior surgeon was working with either another junior surgeon or a resident. In this subgroup, there was a 38% laparotomy rate. It was interesting to see that placing a senior assistant with any level surgeon significantly improved the likelihood of an MIH in Category 3 cases. Since the beginning of this study, we have found a steady increase in clinician experience in MIH procedures. A scoring system is being developed to quantitate the minimal amount of surgeon-assistant experience needed to take on each category of hysterectomy.

Surgical times, as an element of efficiency and value, affect overall utilization of the operating rooms, and categorization can accurately determine how many cases can be performed in an all-day operating room block. The surgical times of 1.5 hours, 2 hours, and 2.5 hours for Categories 1, 2, and 3, respectively, were significantly different. This creates the opportunity to add additional cases to all-day OR blocks with lower-category hysterectomies, leading to a more efficient strategy for operating room scheduling.

Study Strengths and Limitations

The primary strength of this article is that the authors reviewed all 576 hysterectomies for benign disease performed by 39 general gynecologists during an entire year.

The primary weakness is that this is an observational and retrospective study. We assigned surgeons to junior, midlevel, and senior on the basis of years of surgical experience and volumes of MIH cases performed. The technique for doing our surgeries did not change over the study period and did not require the use of power morcellation. When morcellation was required, it was primarily performed vaginally or via a 4-cm minilaparotomy. We have attempted to improve other perioperative parameters that could affect surgical times but have not found obvious improvement, especially during our study period. We believe that by using our patient characteristics categorization system, our comparisons were looking at equally difficult hysterectomies, thereby removing most bias.

CONCLUSIONS

We demonstrated that categorization of hysterectomies into three categories of complexity enables the surgeon to better predict the difficulty of hysterectomy and to determine the average operating time and the need for experienced surgical assistants while increasing our MIH rates safely and efficiently.

Categorizing hysterectomies for benign disease also allows much more research to be done on equally difficult surgeries. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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