Perioperative Outcomes of Robotically Assisted Hysterectomy for Benign Cases With Complex Pathology

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OBJECTIVE: To report on the perioperative outcomes after robotically assisted total hysterectomy for benign indications in a large patient population with predominantly complex pathology.

METHODS: One hundred fifty-two patients underwent robotic hysterectomy for noncancer indications from May 2005 to May 2008. A systematic chart review of consecutive robotic cases was conducted based on preoperative and perioperative characteristics of each patient. Each case was evaluated for its complexity based on preoperative diagnosis, prior pelvic or abdominal surgery, patient's body mass index, and uterine weight.

RESULTS: The overall operative time was 122.9 minutes, estimated blood loss was 79.0 mL, and there were three (2.1%) intraoperative complications, with no perioperative blood transfusions or conversions. There were five (3.5%) patients with postoperative complications, and length of hospital stay was 1.0 days on average. Of the characteristics indicating complexity, only uterine weight greater than 250 g resulted in significantly increased operative times, attributable to increased morcellation time.

CONCLUSION: Robotically assisted total hysterectomy for benign indications in patients with complex pathology is feasible, with low morbidity and a short hospital stay. This study suggests that robotic assistance facilitates the use of a minimally invasive approach in high-risk patient populations.
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Minimally invasive surgical techniques for performing hysterectomy have been shown to reduce patient morbidity and shorten hospital stay.[1,2] Although there have been reports of the successful use of laparoscopic techniques for obese patients[3] and patients with large uteri,[4–7] surgeons are often limited in the complexity of the procedures that they can perform using conventional laparoscopy.

A robotic system (da Vinci Surgical System, Intuitive Surgical, Inc., Sunnyvale, CA) is designed to address many of the limitations of conventional laparoscopy, and these benefits may allow for a minimally invasive approach in more complex cases, demonstrating the feasibility and safety of this technology as effective without increasing morbidity. However, although there have been several pilot studies on alternatives to laparoscopic hysterectomy for both benign and oncologic indications,[8–14] to date there have only been two larger-scale studies of robotic-assisted total hysterectomy specifically for benign indications.[15,16] In addition, the advantages of robotics may become even more apparent in complex cases, where the use of conventional laparoscopy is traditionally contraindicated. For example, one study reported success in treating six patients for pelvic adhesive disease with robotic-assisted total hysterectomy with good patient outcomes.[17]

As a gynecologic oncology practice at a teaching institution,[18,19] the benign cases that we see are often

complex cases. In this study we sought to investigate whether robotic assistance facilitates the surgery and results in low morbidity and acceptable perioperative outcomes.

MATERIALS AND METHODS

Implementation of a robotics program took place at our institution in May 2005. One hundred fifty-two patients underwent robotic hysterectomy for noncancer indications from May 2005 to May 2008. A systematic chart review of consecutive robotic cases was conducted based on preoperative and perioperative characteristics of each patient. Each case was evaluated for its complexity based on preoperative diagnosis, prior pelvic or abdominal surgery, patient's body mass index (BMI), and uterine weight. Prior pelvic or abdominal surgery was categorized as a dichotomous variable (ie, presence or absence), as was surgical indication of leiomyomas or endometriosis (ie, presence or absence of leiomyoma or endometriosis). Body mass index was categorized based on patients with BMI less than 30 or those with BMI of 30 or greater. Uterine weight was categorized using a threshold value of 250 g. All cases were further categorized as being teaching cases or nonteaching cases. Before the commencement of this study, institutional review board approval was obtained from the University of North Carolina at Chapel Hill for data collection on patients who consented. One experienced surgeon performed the majority of cases with resident and or fellow assistance for 44.7% of cases. In those cases, an attending or resident performed parts of the robotic procedure at the console with supervision. The level of resident involvement was based on the complexity of the case, with the experienced surgeon performing the more complex cases. Data analyses were conducted using SAS 9.1.3 software (SAS Institute, Inc, Cary, NC). Frequencies or means with standard deviation and 95% confidence intervals were reported. Regression modeling based on the previously mentioned independent variables and their categorizations was carried out to determine what factors influenced operative time. Results of this study were contrasted to similar studies in the published literature.

Patients included in this study had hysterectomy for benign gynecologic conditions. All cases were performed under general endotracheal anesthesia. Antibiotics were given just before surgery. Patients were placed in dorsal lithotomy position with Allen

Table 1. Preoperative Characteristics

Characteristic	n	%	Mean±SD	95% CI	Range
Age (y)	152		46.9±9.4	(45.1–48.1)	(23.0–88.0)
Body mass index	152		30.7±8.7	(29.2–32.0)	(17.0–63.3)
Obese (more than 30)	73	48.0			
Morbidly obese (40 or more)	25	16.4			
Uterine weight (g)	152		347.0±389.2	(280.5–403.8)	(44.0–2,140.0)
More than 250 g to less than 500 g	33	21.7			
500 g or more	29	19.1			
Race					
African American	26	17.1			
Asian	2	1.3			
White	120	79.0			
Hispanic	4	2.6			
Prior pelvic or abdominal surgery					
None	58	38.2			
1 occurrence	71	46.7			
2 occurrences or more	23	15.1			
Type of procedure					
Hysterectomy + BSO or hysterectomy + USO	148	97.3			
Hysterectomy BSO or USO + other	4	2.7			
Indication for surgery					
Adnexal mass	22	14.4			
Endometriosis/leiomyomas	52	34.2			
BRCA/family history	10	6.5			
Postmenopausal bleeding	2	1.3			
Hyperplasia	12	7.9			
Dysplasia	14	9.2			
Other	44	26.5			

SD, standard deviation; CI, confidence interval; BSO, bilateral salpingo-oophorectomy; USO, unilateral salpingo-oophorectomy.

stirrups (Allen Medical Systems, Acton, MA) for lower extremity positioning. A Zumi System uterine manipulator with balloon tip (Cooper Surgical, Trumbull, CT), KOH Colpotomizer System and vaginal pneumooccluder balloon (Cooper Surgical) were placed after appropriate preparation and draping. Patients were placed in a steep Trendelenburg position, with arms tucked at the sides and shoulder blocks placed to limit shift on the operating room table. All cases were started using a 2-mm laparoscopic port placed in the left-upper quadrant of the abdomen, midclavicular line and 2 cm below the costal margin. This approach allows for insufflation of CO_2 and allows for the survey of the abdomen with a 2-mm laparoscope to assess pathology and the presence of abdominal adhesions. This technique is particularly helpful in patients with prior abdominal surgery, where placement of a trocar within the prior surgical field would be hazardous. In addition, it allows placement of all larger trocars under direct visualization after the abdomen has been insufflated. It is important to place an oral–gastric tube at the beginning of the case to prevent trauma to the stomach. Three to four bladeless trocars were placed in the patient's abdomen, two 8-mm robotic trocars, and one extra-long 12-mm trocar for the camera. An additional 8-mm robotic trocar was placed on selected cases where additional retraction was necessary. Finally, the original 2-mm port was replaced with a 5-mm port to allow the bedside surgical assistant to use a grasper or suction-irrigation device. The robotic system was then docked between the legs. All cases were performed using monopolar EndoWrist scissors (Intuitive Surgical, Inc.) combined with the bipolar fenestrated grasper. Hysterectomies were performed according to the American Association of Gynecologic Laparoscopists type IVE hysterectomy using the KOH Colpotomizer System (Cooper Surgical). The American Association of Gynecologic Laparoscopists type IVE hysterectomy is defined as total laparoscopic removal of the uterus and cervix including vaginal cuff closure.

All pathologic specimens were removed using one of the four following methods: direct removal through the vaginal cuff opening, morcellation of the specimen using an endoscopic morcellator, sectioning of the uterine specimen with robot using an EndoWrist monopolar cautery instrument (Intuitive Surgical, Inc.) to portions small enough to be delivered vaginally, or by minilaparotomy with manual morcellation for three cases where the uterus was more than 2,000 g. The vaginal cuff was closed robotically using 0 polyglactin (Vicryl, Ethicon Endo-Surgery, Inc., Cincinnati, OH) on a CT-1 needle in a running suture closure. Tension was maintained throughout the cuff closure by the assistant using a needle driver to hold

Table 2. Operative Characteristics

	n	%	Mean±SD	95% CI	Range
Docking time* (min)	152		17.8±8.2	(16.3–19.2)	(5.0–50.0)
Operative time† (min)	152		122.9±48.3	(116.6–132.3)	(43.0–325.0)
Type of cases					
Teaching cases	84	44.7			
Nonteaching cases	68	55.3			
Estimated blood loss	152		79.0±132.1	(58.5–100.0)	(10.0–1,200.0)
Length of stay	152		1.05±0.69	(0.95–1.2)	(0–3.0)
Conversions					
None	152	100			
Intraoperative complications					
Left ureteral injury	1	0.7			
Small bowel enterotomy	1	0.7			
Vaginal laceration	1	0.7			
Total	3	2.1			
Postoperative complications					
Recurrent UTI	1	0.7			
Postoperative UTI	1	0.7			
Postoperative UTI, transient femoral nerve palsy	1	0.7			
Vaginal cuff abscess, pain with intercourse	1	0.7			
Vaginal hematoma	1	0.7			
Total	5	3.5			

SD, standard deviation; CI, confidence interval; UTI, urinary tract infection.
* Docking time reflects the time taken to place ports and dock the robot.
† Operative time reflects the time from the first skin incision to skin closure.

Table 3. Regression Model: The Effects of Preoperative Characteristics on Operative Time

Variable	Parameter Estimate	Standard Error	*t*	*P*
Intercept	83.64	24.72	3.38	<.001
Diagnosis (leiomyomas/endometriosis)	–3.55	9.46	0.38	.708
Uterine weight (250 g or more)	24.33	9.36	–2.60	<.010
Prior pelvic/abdominal surgery	–7.30	8.15	–0.90	.372
Body mass index (more than 30)	8.69	7.94	1.09	.276
Teaching case	4.69	7.95	0.59	.556

Diagnosis is a categorical variable of two levels: presence or absence of leiomyomas or endometriosis.
Uterine weight is a continuous variable categorized as two levels: less than 250 g or 250 g or more.
Adhesions is a categorical variable of two levels: presence or absence of adhesions.
Body mass index is a continuous variable categorized as less than 30 or 30 or more.
Teaching case is a categorical variable of two levels: teaching or nonteaching case.

the suture tight as the subsequent stitch was placed. Sutures were instrument-tied using the robotic instruments. Patients were desufflated, and pedicles were checked at half desufflation for hemostasis. The robotic system was then undocked, and all trocars were removed under direct visualization. The 12-mm trocar sites received a single deep 0-polyglactin suture, and all skin incisions were closed with 4–0 polyglactin subcuticular sutures. Adhesive skin closures (Steri-Strips, 3M, St. Paul, MN) were placed as dressing.

The following times were recorded: docking time, defined as the time from first incision to placement of the robotic instruments into the patient; morcellation time; and total operative time, defined as first skin incision to wound closure. In addition, uterine weight, blood loss, transfusion rate, conversions, intraoperative and postoperative complications requiring intervention, as well as length of hospital stay were monitored and recorded. Cases were stratified based on the level of complexity using BMI, uterine weight, presence of prior pelvic or abdominal surgeries, and preoperative diagnosis. We also report outcomes for subgroups of patients with uterine weight of 500 g or more, or BMI of 30 or more.

RESULTS

A total of 152 consecutive patients underwent hysterectomy with robotic assistance for benign indications between May 2005 and May 2008. Patient characteristics and surgical indications are listed in Table 1. The patients were on average aged 46.9±9.4 years (range 23.0–88.0 years) with a BMI of 30.7±8.7 (range 17.0–63.3). There were 48% of patients who were considered obese based on having a BMI equal to or exceeding 30 and 16.4% who were morbidly obese based upon a BMI greater than 40. Endometriosis or leiomyomas or both were the main indication for 34.2% of patients. The racial composition of patients included 79% white, 17.1% African-American, 2.6% Hispanic, and 1.3% Asian women. More than 62% of all patients had undergone prior abdominal or pelvic surgery. Of these women 15.1% had undergone multiple prior abdominal or pelvic surgeries. Patients underwent total hysterectomy with (97.3%) or without (2.6%) unilateral or bilateral salpingo-oophorectomy, with 2.6% of patients undergoing additional procedures. The average uterine weight was 347.0±389.2 g (44.0–2140.0 g) with more than 40% of patients having a uterine weight greater than

Table 4. Summary of Reports on Robotic Hysterectomy for Benign Indications

Author	N	BMI	Uterine Weight (g)	Prior Abdominal Surgery	Indications
*Advincula 2005[18]	6	26.0	121.7	6 (100%) (cesarean)	Endometriosis, leiomyomas, bleeding
Beste TM 2005[9]	11	26	49–227	NR	Leiomyomas, bleeding
Fiorentino 2006[11]	20	NR	98	None	Bleeding
Reynolds 2006[14]	16	27.8	131.5	13 (81%)	Endometriosis, leiomyomas, bleeding
Kho 2007[16]	91	27.9	135.5	NR	Bleeding, endometriosis, neoplasm
Payne 2008[17]	100	28.8	266.6	NR	Leiomyomas, endometriosis
Boggess current series	152	30.7	347.0	62%	Leiomyomas, endometriosis

BMI, body mass index; EBL, mean estimated blood loss; LOS, mean length of hospital stay; Blood Tx, blood transfusions; Conversion, any surgical conversion to laparoscopy or open surgery; NR, not reported.
* All patients had pelvic adhesive disease.

250 g and 19.1% of patients with a uterine weight of 500 g or more. One patient received a preoperative transfusion for iron-deficient anemia. Total operative time was on average 122.9 minutes, which included morcellation time when applicable (Table 2).

There were 44.7% of cases in which an attending, fellow in training, or resident performed parts of the robotic procedure at the console with supervision. Although the operative time was longer for these teaching cases (125.5 minutes compared with 119.5, $P=.4$). Patients in this study experienced an average blood loss of 79.0 mL (10.0–1,200.0 mL) with no one requiring a transfusion as a result of the procedure. There were three patients with a blood loss more than 500 mL; in all three cases, uterine weight was in excess of 1,000 g. There were three (2.1%) intraoperative complications that were successfully handled robotically without the need for conversion. These included a vaginal laceration, a ureteral injury, and one bowel injury. There were five (3.5%) patients with seven postoperative complications (occurring within 30 days), which included a patient with transient femoral nerve palsy and urinary tract infection, one patient with a vaginal cuff abscess and pain with intercourse, one vaginal hematoma, and two patients with urinary tract infection, one of which was a result of a preexisting condition. Patients had an average length of stay of 1.05±0.69 days (range 0–3.0 days).

The majority of cases in this cohort underwent hysterectomy for complex pathology. As such, a multiple regression model was used to determine whether predetermined factors affecting complexity influenced operative time. Preoperative diagnosis, evidence of prior multiple pelvic or abdominal surgeries, and BMI did not affect operative time. The only variables that were significantly associated with increased operative time were a large uterus (more than 250 g) and fellow or resident involvement (Table 3). This was true when each variable was taken into account separately as well as collectively.

For the purpose of observational comparison to articles in the literature reporting on patient populations with complex pathology, specifically a uterine weight 500 g or more or BMI 30 or more, similar subgroups are presented below. In the subgroup of patients with uterine weight 500 g or more, overall operating time was 155.8±67.6 minutes (range 68.0–325.0 minutes), with an average morcellation time of 41.6 minutes. Blood loss in this subgroup was 135.3±236.8 mL (range 25.0–1200.0 mL), with one (1.3%) intraoperative vaginal laceration and one (1.3%) postoperative vaginal hematoma. Average hospital stay for this subgroup was 1.0±0.3 days (range 1.0–2.0 days). In the subgroup of patients (BMI 30 or more), overall operating time was 130.8±48.8 minutes (range 60.0–325.0 minutes). Blood loss in this subgroup was 103.3±182.0 mL (range 10.0–1200.0 mL), with two (2.6%) intraoperative complications, including one ureteral injury and one vaginal laceration previously reported in the subgroup above (500 g or more uterine weight). There were two (2.6%) postoperative urinary tract infections. Average hospital stay for this subgroup was 1.0±0.3 days (range 1.0–3.0 days).

DISCUSSION

This study presents our experience with robotic-assisted total hysterectomies for benign indications in 152 consecutive cases. All were successfully completed robotically without the need for conversion. We report on patients with complex pathology and demonstrate a lack of perioperative blood transfusions, a short hospital stay, low blood loss, low morbidity rates, and short operative times. In addition, the only factors that extended operative times were resident or fellow involvement or a large uterus. The latter can be explained by increased morcellation time, rather than an increased difficulty of the surgery.

With the development of minimally invasive techniques, outcomes after total hysterectomies have improved over those seen after abdominal hysterec-

Operative Time (min)	EBL (mL)	LOS (d)	Complications [n (%)]	Blood Tx	Conversion [n (%)]
254	87.5	1.3	1 (16.7) postoperative	0	0
192	25–350	NR	2 (18.2) intraoperative	0	1 (9.1)
192	81	2	1 (5) postoperative	0	2 (10)
242	96	1.5	4 (25) postoperative	0	0
127.8	78.6	1.35	1 (1.1) intraoperative, 7 (7.7) postoperative	0	0
119.4	61	1.1	1 (1.0) intraoperative, 1 (1.0) postoperative	0	4 (4.0)
122.9	79.0	1.0	3 (2.0) intraoperative, 5 (3.5) postoperative	0	0

Table 5. Summary of Reports on Laparoscopic Hysterectomy for Benign Indications

Author	N	BMI	Uterine Weight (g)	Prior Abdominal Surgery (%)	Indications (%)
Perino 1999[25]	51	NR	368	NR	Bleeding, leiomyomas
Chapron 2000[22]	105	24.7	NR	33	Leiomyomas 20
Gyr 2001[23]	48	NR	270	NR	Leiomyomas 89
Wattiez 2002 (1996–1999)[26]	952	23.8	292	95.2	Leiomyomas 44, endometriosis 4.2
Wattiez 2002 (large uteri)[7]	34	NR	617†	47.0	Leiomyomas, bleeding
Seracchioli 2002[5]	60	24.7	411.8†	31.6	Leiomyomas
Seracchioli 2003 (no GnRH)[4]	31	24.4	462†	Excluded	Bleeding 83.9
Malzoni 2004 (2000–2002)[24]	624	24.8	408	15.4	Leiomyomas
Sizzi 2004[6]	22	NR	413.4†	37	Severe endometriosis
Leonard 2005[21]	416	21.1	245.9	31.7	Severe endometriosis 7.2, leiomyomas 66.8
Bonilla 2007[1]	202	NS	203.1	83.2	NS
Boggess (current series)	152	30.7	347.0	62	Leiomyomas, endometriosis

N, number of patients; EBL, mean estimated blood loss; LOS, mean length of hospital stay; Blood Tx, blood transfusions; NR, not reported; NS, data not separated by group.
* Converted to laparoscopically assisted vaginal hysterectomy.
† All patients had large uteri.

tomy.[20] However, in a study by Leonard et al[21] the authors showed that BMI, uterine size, leiomyoma size, and a history of adhesion-causing abdominopelvic surgery are all independent risk factors for intraoperative conversions from laparoscopy to laparotomy. In addition, Bonilla et al[1] demonstrated that a large uterus increased the risk of a longer hospital stay, increased morbidity, and increased blood loss. Thus, these characteristics provide a measure of the complexity and potential difficulty of a surgery.

With extensive experience performing robotic radical hysterectomies to treat cervical cancer[19] and robotic total hysterectomies with lymph node dissection and bilateral salpingo-oophorectomy to treat endometrial cancer,[18] the primary surgeon was able to perform robotic total hysterectomies on obese patients, patients with one or more prior pelvic or abdominal surgeries, patients with moderate to severe endometriosis or leiomyomas, and patients with large uteri without conversion to laparotomy and with excellent patient results. In addition, the only factor influencing operative time, was a uterine size more than 250 g, which was due to an increase in morcellation time, rather than an increase in the difficulty of surgery.

Although the literature on the use of robotic surgery for hysterectomies for benign conditions is

Table 6. Summary of Reports on Laparotomy Hysterectomy for Benign Indications (All Comparative Studies)

Author	N	BMI	Uterine Weight (g)	Prior Abdominal Surgery (%)	Indications
De Meeus and Magnin 1997[30]	62	NR	608.53	40.3 pelvic, 4.8 laparotomy	Bleeding
Marana et al 1999[36]	58	NR	352.3	In some	Leiomyomas, bleeding
Chapron et al 1999[28]	94	25.5	354	17.0	Leiomyomas, bleeding
Falcone et al 1999[31]	21	28.9	309	79.2	Leiomyomas 87.5%, endometriosis 8.3%
Perino et al 1999[25]	51	NR	389	NR	Leiomyomas, bleeding
Chapron et al 2000[22]	30	22.2	NR	47	Leiomyomas 20%
Makinen et al 2001[35]	5875	NR	290.4	NR	Leiomyomas, bleeding, endometriosis
Benassi et al 2002[27]	59	56.1	436	Excluded	Leiomyomas
Gyr et al 2001[23]	96	NR	296	NR	Leiomyomas 91.7%
Seracchioli et al 2002[5]	62	23.1	429.6	24.1	Leiomyomas
Harmanli et al 2004[32]	200	NR	737.4	NR	Leiomyomas 94%, endometriosis 2.5%
Kafy et al 2006[33]	1349	26.4	335.8	NR	Leiomyomas 60%, bleeding 40%
David-Montefiore et al 2007[29]	155	26.1	723	36.5 pelvic, 21.8 cesarean	Pain 40%, bleeding 54.6%
Leung et al 2007[34]	934	NR	427*	NR	Leiomyomas 73.7%, endometriosis 5.4%

N, number of patients; EBL, mean estimated blood loss; LOS, mean length of hospital stay; Blood Tx, blood transfusions; NR, not reported.
* Data missing for 259 cases.

Operative Time (min)	EBL (mL)	LOS (d)	Complications [n (%)]	Blood Tx [n (%)]	Conversion [n (%)]
104.1	140	2.4	2 (4.0) postoperative	0	0
135	NR	3.0	1 (0.9) intraoperative, 7 (6.7) postoperative	0	0
85	80	3	1 (2.1) intraoperative, 3 (6.3) postoperative	0	0
90	NR	NR	18 (1.9) intraoperative, 16 (1.7) postoperative	1 (0.1)	4 (0.4)†
159.8	NR	3.6	2 (5.9) intraoperative, 4 (11.8) postoperative	0	0
95.2	311.6	1.3	8 (13.3) postoperative	0	1 (1.7)
115.3	NR	3.35	0 intraoperative, 4 (12.9) postoperative	3 (9.7)	3 (9.7)
80	NR	2.3	3 (0.5) intraoperative, 32 (5.1) postoperative	1 (0.2)	4 (0.6)
125	NR	2.1	2 (9.1) postoperative	0	0
141.7	NR	3.5	8 (27.6) intraoperative	NR	29 (7)
123.6	150.7	1.45	28 (13.9) postoperative	NR	NR
122.9	79.0	1.0	3 (2.0) intraoperative, 5 (3.5) postoperative	0	0

sparse, as seen in Table 4, there are a few recent studies reporting on large patient populations.[15,16] However, our average BMI and uterine weight are higher than other published studies[8,10,13,15–17] (Table 4). The incidence of prior abdominal surgery is similar for those studies that have included this measure, whereas the operative time for this study is at the lower end of the range reported (122.9 minutes compared with 119.4–254 minutes). The estimated blood loss for this study at 79.0 mL is within the range of averages reported for all benign robotic hysterectomy studies to date, most of which report on noncomplex cases (61–102.5 mL). The length of stay for all of the robotic studies reported is within 1.5 days, with the majority of patients discharged in 1 day. One striking difference in the robotic reports as compared with both the laparoscopic and laparotomy reports (seen in Table 4 and 5, respectively) is the complete lack of blood transfusions. In addition, even with many highly complex surgeries, there were no conversions in our study. Complication rates for our study are comparable to the two other reports on a large patient population.[15,16]

We also contrasted our results to those of other studies reporting on the outcomes after complex laparoscopic total hysterectomies. Our criteria for categorizing hysterectomy as complex were high BMI, large uterine weight, prior major pelvic or

Operative Time (min)	EBL (mL)	LOS (d)	Complications [n (%)]	Blood Tx [n (%)]
90	384.5	8.1	1 (1.6) intraoperative	0
91.8	353.9	5.9	7 (12.1) postoperative	2 (3.4)
NR	NR	6.9	8 (8.5) intraoperative, 22 (23.4) postoperative	5 (5.3)
130	250	2.5	5 (23.8) postoperative	3 (14)
87.8	406	6.2	6 (11.8) postoperative	1 (2.0)
100	NR	8.1	12 (40) postoperative	0
86.1	305.1	6.0	2.3% intraoperative, 12.3% postoperative	NR
102	NR	4.3	24 (40.7) postoperative	4 (6.8)
65	200	6	1 (1.0) intraoperative, 11 (11.5) postoperative	0
88.6	376.9	2.03	1 (1.6) intraoperative, 25 (40.3) postoperative	1 (1.6)
137.4	NR	3.7	4 (2.0) intraoperative, 73 (36.5) postoperative	11.5%
NR	NR	NR	7 (0.5) intraoperative, 53 (3.9) postoperative	0.74%
124.4	NR	7.6	3 (1.9) intraoperative, 21 (13.5) postoperative	5 (3.2)
89	320	6.7	8 (0.9) intraoperative, 270 (28.9) postoperative	40 (4.3)

abdominal surgery, and surgical indications, including endometriosis and leiomyomas[1,4–7,21–26] (Table 5). When compared with these studies with similar patient characteristics, we report equivalent operative times at 122.9 minutes compared with the reported range in the literature of 80–159.8 minutes, lower blood loss of 79.0 mL compared with a range of 80–311.6 mL, a shorter length of stay of 1.0 day compared with a range of 1.3–3.6 days, and lower complication and conversion rates.

For the purposes of observational comparison of our results to those published in the literature, we report on the outcomes for patients with uterine weight 500 g or more or high BMI. When we specifically compare our results for the subgroup of patients with uterine weight 500 g or more, we report an increase in operative time of 30 minutes, due to increased morcellation time, an increase in blood loss of approximately 50 mL, and no increases in length of stay. When comparing this subgroup with a conventional laparoscopic study where all patients also had uterine weights more than 500 g, we see equivalent operative times, a shorter length of stay, and fewer intraoperative and postoperative complications.[7]

Upon examining our results for the subgroup of patients with a BMI greater than or equal to 30, we see very small increases in operative time (approximately 10 minutes) and in blood loss (approximately 20 mL) with no increase in length of stay. When we again compare our results with conventional laparoscopic hysterectomy in obese patients, we report a shorter operative time by approximately 30 minutes, lower blood loss by approximately 60 mL and shorter hospital stay.[3]

We also contrast our results to those reported after total hysterectomy by laparotomy[5,22,23,25,27–36] (Table 6). Similar criteria were used for choosing these comparative studies. The literature result for total abdominal hysterectomy reports similar operating times, greater blood loss, and longer hospital stays. One of the concerns with conventional laparoscopy has been an increased rate of intraoperative complications. Our intraoperative complication rate at 2.1% was within the range reported in the abdominal hysterectomy studies (0.5–2.3%), with one study reporting an intraoperative complication rate of 8.5%. We report a postoperative complication rate of 3.5% compared with a low of 3.9% and a range of 11.5–40.7% for abdominal hysterectomy studies.

Limitations of this study include the fact that we do not report data for concurrent laparoscopic or abdominal cohorts for comparison, that the generalizability of the results may be limited due to the level of experience of the primary surgeon, and that residents assisted mainly on the less complex cases.

This study represents a large cohort of patients treated with robotic-assisted total hysterectomies for complex benign indications. Even in patients with several high-risk factors, we demonstrate a short hospital stay and minimal blood loss, with no conversions. This suggests that the increased precision and dexterity afforded by the use of robotic assistance allows for a safe and efficient surgery even for patients with complex pathology. Ideally, these results should be confirmed by future comparative studies.

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