Current Role of Robotic Hysterectomy

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Abstract

Background: While robotic surgery for gynecologic indications received U.S. government approval in 2005, and has been rapidly and widely adopted, it is currently unclear how often this approach to hysterectomy is utilized. **Objective:** The aim of this research was to assess length of stay (LOS), mortality, indications, and current use of robotic hysterectomy, compared to other types of hysterectomy. **Methods:** A retrospective study of hysterectomies performed in New York State (NYS) in 2011 was performed. Data, including indication for surgery, age, procedure, LOS, and discharge status were obtained from the NYS Department of Health Statewide Planning and Research Cooperative System (SPARCS). **Outcome Measures:** LOS and mortality rate, were calculated according to institution, procedure, and indication for surgery. **Results:** For 22073 hysterectomies performed in NYS, the mean LOS was 2.9 days, and there were 29 (0.13%) deaths. The mean LOS for abdominal (12774 cases, 3.9 days) hysterectomies was longer than for laparoscopic (3927 cases, 1.6 days), robotic (2814 cases, 1.6 days), or vaginal (2558 cases, 1.7 days) hysterectomies ($p < 0.05$). The adjusted mortality rates for abdominal (0.20%), laparoscopic (0.03%), robotic (0.07%), and vaginal (0.04%) hysterectomies were not significantly different. Overall, robotic surgery was performed in 29% of hospitals, by 11% of physicians and in 13% of cases. A robotic approach was utilized in 35% of patients with uterine cancer, 13% with endometriosis, 11% with excessive bleeding, 8% with leiomyomata, and 8% with pelvic relaxation. **Conclusions:** Despite the advantages in reduced LOS for robotic and other minimally invasive types of hysterectomies, the abdominal route is still predominant in most institutions. (J GYNECOL SURG 29:174)

Introduction

ALTHOUGH ROBOTIC SURGERY for gynecologic indications, first approved by the Food and Drug Administration in 2005, has been rapidly and widely adopted, it is currently unclear how often this approach to hysterectomy is utilized. Since 2005, the da Vinci robotic system (Intuitive Surgical, Sunnyvale, CA) has been installed at 1718 hospitals worldwide, with 89 of these systems in New York State alone.¹ Compared to abdominal procedures, the primary advantages of this minimally invasive approach are reductions in wound infections, blood loss, and length of stay (LOS), as well as more rapid return of patients to normal activities.²

Although the advantages of robotic surgery, compared to surgery via an abdominal route, are increasingly apparent, the majority of practicing gynecologists in the United States completed residency prior to the introduction of this system. In addition, training in robotic surgery is not part of all residency programs; according to a recent nationwide survey, training in robotics was part of the curriculum in 58% of programs.³ Also, as is true for vaginal and conventional

laparoscopic hysterectomies, a robotic approach may not be suitable for all conditions requiring surgery.

Hysterectomy is the most common nonobstetric major surgical procedure performed in women in the United States, with ~600,000 cases each year.⁴ In many instances, and for most indications, a robotic approach should be possible.

This study was conducted to evaluate all hysterectomies done in 2011 in New York State (NYS). The objectives were to determine types of hysterectomy performed according to indication for surgeries and to assess how frequently a robotic approach was used. In addition, LOS and mortality were evaluated according to indications for surgery.

Materials and Methods

The study was submitted to the University of Rochester Medical Center's review board. Because patient-specific information was not obtained, the study was approved with exempt status.

The NYS Department of Health Statewide Planning and Research Cooperative System (SPARCS) is a statewide

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TABLE 1. HYSTERECTOMY OUTCOMES: AGE, LENGTH OF STAY AND MORTALITY IN TEN HIGHEST-VOLUME INSTITUTIONS STATEWIDE IN NYS

<i>Institution</i>	<i>Cases</i>	<i>% Robotic</i>	<i>Mean age (yrs)</i>	<i>Mean LOS (days)</i>	<i>Deaths N (%)</i>
Highland	695	55	53.8	2.5	1 (0.14)
Memorial Sloan Kettering	684	38	57.5	3.7	0
Mt. Sinai	617	6	55.2	3.3	1 (0.16)
Millard Filmore	616	23	52.4	2.6	0
Winthrop	579	31	53.9	2.4	1 (0.17)
North Shore	574	14	54.6	3.1	1 (0.17)
Rochester General	550	62	50.1	1.7	0
Long Island Jewish	479	31	53.7	2.6	0
Sisters of Charity	473	28	50.8	2.5	2 (0.42)
Good Samaritan	451	2	52.6	3.2	1 (0.22)
Subtotals	5718	30	53.6	2.8	7 (0.12)
NYS Totals	22073	13	51.4	2.9	29 (0.13)

NYS, New York State, LOS, length of stay.

database established in 1979 that includes information on all in-patient and ambulatory surgeries. Law mandates reporting by all NYS hospitals.⁵ This system was accessed to review all hysterectomies performed from January 1, 2011 to December 31, 2011.

Using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), searching for procedure codes 68.3 to 68.9 (hysterectomy), 22,073 cases were identified. Demographic information, including patient age, ethnicity, indication for admission, and insurance were collected. In addition, the procedure performed, LOS, and discharge status (home, death, etc.) were noted. Data on cost is not part of the SPARCS database and, thus, could not be ascertained as part of this study.

The data were analyzed to determine two primary outcome measures: (1) LOS and (2) mortality. This was done according to institution, procedure performed, and indication for the procedure. An evaluation was performed on the number of hospitals and physicians statewide performing four types of hysterectomy: (1) robotic; (2) laparoscopic; (3) vaginal; and (4) abdominal.

Univariate and multivariable analysis of LOS and mortality were performed to eliminate potential confounders. Statistical testing was performed using SPSS version 20 and included *Chi*-square, analysis of variance, and *t*-testing for unadjusted analysis as well as logistic and linear regression for multivariate analysis.

Results

In NYS in 2011, 22073 hysterectomies were performed with 29 (0.1%) deaths. Overall, the mean LOS and mean patients' age were 2.9 days and 51.4 years old. There was a significant relationship between age and LOS, with a LOS of 2.6 days for patients <50 years old, 3.2 days for patients ≥50, and 4.6 days for patients age ≥75 ($p < 0.0001$).

The ten highest-volume institutions are listed in Table 1. These ten hospitals varied in case volume (451–695 cases), percentage of robotic cases, (2%–62%), mean patients age' (50.1–57.6 years), mean LOS, (1.7–3.7 days), and mortality (0–0.4 deaths per 100 hysterectomies). The top 10 institutions accounted for 26% of the hysterectomies done statewide. Although the mean patients' age among the ten highest-volume institutions was significantly different from the lower-volume institutions (age 53.6 versus age 50.6), this difference was not of clinical significance and there was no significant difference in LOS (2.8 days versus 3.0 days). The mean mortality rate for the ten highest-volume institutions did not differ from lower-volume institutions (0.12% versus 0.13%). The percentage of robotic cases in the ten-highest volume institutions was 30% versus 7% for lower-volume institutions ($p < 0.001$).

Abdominal hysterectomy was the most frequently performed procedure, accounting for 58% (12774/22073) of cases, and, as expected had the longest LOS, with a mean of

TABLE 2. HYSTERECTOMY TYPE: AGE, LOS AND MORTALITY

<i>Type of hysterectomy</i>	<i>Cases N (%)</i>	<i>Mean age (yrs)</i>	<i>Mean LOS (days)</i>	<i>Deaths N (%)</i>	<i># Hospitals N (%)</i>	<i># Physicians N (%)</i>
Abdominal	12,774 (58)	50.4	3.9	25 (0.20)	176 (99)	2056 (90)
Laparoscopic	3927 (18)	49.0	1.6	1 (0.03)	145 (82)	893 (39)
Robotic	2814 (13)	54.5	1.6	2 (0.07)	51 (29)	255 (11)
Vaginal	2558 (12)	56.7	1.7	1 (0.04)	154 (87)	691 (30)
Totals	22073	51.4	2.9	29 (0.13)	178	2282

LOS, length of stay.

TABLE 3. INDICATIONS AND TYPES OF HYSTERECTOMIES: AGE, LOS, AND MORTALITY

Indications ^a and types of hysterectomies	Cases N (%)	Mean age (years)	Mean LOS (days)	Deaths N (%)
Leiomyomata	8980 (41)	46.7	2.5	2 (0.02)
Abdominal	6296 (70)	46.7	2.9	2 (0.03)
Laparoscopic	1597 (18)	46.5	1.5	0
Robotic	707 (8)	47.7	1.4	0
Vaginal	380 (4)	46.8	1.7	0
Pelvic relaxation	2710 (12)	60.4	1.8	1 (0.04)
Abdominal	578 (21)	58.8	2.2	0
Laparoscopic	284 (10)	57.8	1.5	0
Robotic	217 (8)	57.8	1.4	0
Vaginal	1631 (60)	61.8	1.7	1 (0.06)
Uterine cancer	2491 (11)	63.1	3.4	8 (0.32)
Abdominal	1196 (48)	62.6	4.9	6 (0.50)
Laparoscopic	379 (15)	64.2	2.4	1 (0.26)
Robotic	874 (35)	63.2	1.8	1 (0.11)
Vaginal	42 (2)	62.4	2.3	0
Excessive bleeding	1197 (5)	42.7	1.9	0
Abdominal	531 (44)	42.8	2.5	0
Laparoscopic	384 (32)	42.8	1.5	0
Robotic	137 (11)	43.6	1.4	0
Vaginal	145 (12)	40.9	1.5	0
Endometriosis	988 (4)	43.0	2.3	0
Abdominal	521 (53)	42.5	3.0	0
Laparoscopic	292 (30)	41.8	1.4	0
Robotic	131 (13)	44.2	1.4	0
Vaginal	44 (4)	43.0	1.6	0

^aTop 5 indications only.
LOS, length of stay.

3.9 days, as shown in Table 2. Laparoscopic, vaginal, and robotic procedures all had a significantly shorter LOS than the abdominal route ($p < 0.0001$). The crude mortality rate for abdominal hysterectomy (0.20%) was higher than for laparoscopic (0.03%), robotic (0.07%), and vaginal hysterectomy (0.04%; $p = 0.02$). The mean age and LOS for the 29 patients who died were age 64.3 years and 17.2 days, respectively. The deaths occurred among 25 (14%) hospitals with 28 (1.2%) physicians.

While virtually all hospitals performed abdominal hysterectomies (176/178; 99%), and the majority performed laparoscopic (145/178, 81%) and vaginal (153/178; 86%) procedures, only 51 (29%) hospitals performed robotic hysterectomy. Most physicians (90%) performed abdominal hysterectomy, but far fewer utilized the laparoscopic (39%) or vaginal routes (30%), and only 11% of physicians performed robotic hysterectomy.

The five most frequent indications for hysterectomy with types of procedure performed are shown in Table 3, along with the corresponding mean LOS and mortality rates. Leiomyomata were the most frequent (41%) indication for hysterectomy, and the majority (70%) of patients with this diagnosis underwent abdominal procedures. For patients with pelvic relaxation, vaginal hysterectomy was the most frequent approach (60%). For uterine cancer, abdominal hysterectomy was still the most frequent route (48%), although robotic hysterectomy was performed in 35% of cases. Of note, for uterine cancers, the abdominal approach had a mean LOS of 4.9 days, versus 1.8 days for robotic surgery ($p < 0.0001$), with a nonsignificant difference in mortality

(0.5% versus 0.1%; $p = 0.13$). A robotic approach was used more than twice as often as a laparoscopic approach, with the latter having a significantly longer LOS than a robotic approach (2.4 days versus 1.8 days; $p = 0.005$), although, again, this was of little clinical relevance.

TABLE 4. MORTALITY AND LOS: RESULTS OF MULTIVARIATE ANALYSIS

Factor	OR	95% CI
Mortality		
Age	1.07	1.04 to 1.10
High physician surgical volume (at or above 50th percentile)	0.11	0.05 to 0.23
Top five indications	0.32	0.15 to 0.69
LOS	β Coefficient	95% CI
Age	0.04	0.04 to 0.04
Institution (top quartile)	0.23	0.13 to 0.34
Other race	0.22	0.09 to 0.34
Black race	0.47	0.34 to 0.59
Medicare/Medicaid	0.43	0.33 to 0.54
High physician surgical volume (at or above 50th percentile)	-2.23	-2.41 to -2.05
Robotic	-2.20	-2.35 to -2.05
Vaginal	-2.03	-2.18 to -1.87
Laparoscopic	-1.97	-2.10 to -1.84
Top five indications	-1.55	-1.66 to -1.44

OR, odds ratio; CI, confidence interval; LOS, length of stay.

A univariate analysis of potential confounders for mortality was performed, and following logistic regression (Table 4), it was found that high physician surgical volume (at or above the 50th percentile) and top five diagnoses (leiomyomata, pelvic relaxation, etc.) were associated with lower mortality (odds ratio [OR] 0.11 and OR 0.32, respectively), and greater age in years were associated with higher mortality (OR 1.07). With adjustment, type of hysterectomy was not associated with mortality.

Following a similar analysis of potential confounders for LOS, including hospital volume, it was found that age, institution (top quartile in volume), non-Caucasian race, and Medicare/Medicaid insurance were independently associated with increased LOS. Minimally invasive surgery (laparoscopic, robotic, vaginal), high-volume surgeon, and an admitting diagnosis among the top five indications for surgery were all associated with a shorter LOS (Table 4).

Discussion

Hysterectomy is the most common gynecologic procedure performed in women in the United States.⁶ It is estimated that, by age 65, one-third of women will have undergone this procedure.⁴ Although historically a vaginal approach was the first to be described, over time, the abdominal route has become predominant and today remains the most commonly selected type of hysterectomy.^{7,8}

Of the 22,073 hysterectomies performed in NYS in 2011, an abdominal approach was utilized in 12,774 (58%) of cases. Although an abdominal route may be preferred in many cases, in the current study, it was associated with the longest LOS, at 3.9 days, and the highest crude mortality rate, at 0.20%. However, when the crude mortality rate was adjusted for potential confounders, there was no difference between abdominal hysterectomy and other minimally invasive types of surgery.⁸ The continued dominance of abdominal hysterectomy is undoubtedly related to several factors, with patient selection and physician training playing important roles. In the past, physicians were only trained in abdominal or vaginal hysterectomy. It is only in the past few decades that a laparoscopic approach has been utilized and only in the last few years that a robotic approach has even been an option.

Harry Reich, MD, performed the first laparoscopic hysterectomy in 1989, but this approach has never become dominant, accounting for no more than 10%–25% of hysterectomies nationwide.^{7,9} Although this technique is certainly suitable for simpler surgeries, only a few highly skilled practitioners have been able to utilize it for the wide spectrum of indications and pathologic conditions that require hysterectomy. According to an American Congress of Gynecologists workforce report published in 2011 by Rayburn, the 50th percentile for the total number of abdominal and laparoscopic hysterectomies for residents graduating in 2008 were 69 and 20, respectively, demonstrating the continued dominance of abdominal hysterectomy in training programs in the United States two decades after laparoscopic hysterectomy was first described.¹⁰

The advent of robotic hysterectomy in 2005, a seminal event in the field of gynecology, has been followed by the rapid and widespread adoption of this technology at institutions across the United States. According to recent data from Intuitive Surgical, Inc. (Sunnyvale, CA), there are now

1718 sites worldwide with 2132 installed systems.¹ Nevertheless, there are wide variations among institutions in the use of this technique. The percentage of robotic hysterectomies at the 10 highest-volume institutions for hysterectomies in NYS ranged from 2% to 62%. This may be explained in part by the paucity of current physicians trained in robotics, with only 11% of physicians statewide performing this procedure. Nevertheless, a robotic approach was used in 30% of hysterectomies performed at the high-volume institutions.

Based on the data in this study (Table 1), it is clear that a robotic approach can be utilized successfully in the majority of patients undergoing hysterectomy. Highland Hospital, a community hospital with a large component of gynecologic oncology cases, and Rochester General Hospital, which was an early adopter of robotic surgery, currently utilize a robotic approach in >50% of hysterectomies.

These results do not indicate a reduction in mortality with a minimally invasive approach to hysterectomy. With the annual case volume in NYS, this study was not powered adequately to detect small differences in mortality. It is reassuring that, in general, hysterectomy is a very safe procedure and that case-related mortality is infrequent. One of the limitations of this study and the case-related fatality rates that were studied is the lack of information regarding contributors to mortality. The data set that was assessed did not include information that would allow determinations as to whether death was caused by surgical complications or factors related to patients' underlying conditions.

It was found that all of the minimally invasive approaches to hysterectomy had significantly shorter LOS than an abdominal route (Table 2) and that, for the subgroup of patients with endometrial cancer, robotic surgery had a small but definite ($p=0.005$) reduction of LOS (0.6 days), compared to conventional laparoscopic surgery (Table 3). In addition, for patients with endometrial cancer, a robotic approach is now being utilized more frequently than conventional laparoscopy, despite the latter approach being available for a much longer time period.

The five most common indications for hysterectomy in NYS were leiomyomata, pelvic relaxation, uterine cancer, excessive bleeding, and endometriosis. According to the Centers for Disease Control and Prevention, during the period from 2000 to 2004, the three conditions most often associated with hysterectomy were leiomyomata, endometriosis, and pelvic relaxation.⁴ In the NYS data surveyed for the current study, leiomyomata and pelvic relaxation were the most common indications for hysterectomy, but uterine cancer was the third most-frequent indication, perhaps reflecting the increasing incidence of uterine cancer over the last decade.¹¹ As might be expected, type of hysterectomy performed varied with indication. The abdominal route was predominant for leiomyomata, endometriosis, and uterine cancer, while the vaginal route was preferred for pelvic relaxation.

The use of minimally invasive techniques for managing gynecologic conditions is increasing, albeit slowly. In 2005 Jacoby et al. examined nationwide use of laparoscopic, abdominal, and vaginal hysterectomy for benign disease.⁷ The abdominal, laparoscopic, and vaginal routes were utilized in 64%, 14% and 22% of cases, respectively. In the current study of statewide data, including oncology cases and the advent of robotics, the abdominal, laparoscopic, vaginal, and robotic routes were used 58%, 18%, 12% and 13% of the time, respectively.

Conclusions

Will abdominal hysterectomy become an operation of historical interest? Although there are clear advantages in LOS with minimally invasive surgery, the abdominal route is still the dominant type of hysterectomy in NYS and nationwide. Whether robotic hysterectomy—which is feasible in the majority of cases—will supplant abdominal hysterectomy is unclear. The future role of robotic hysterectomy, as well as the roles of other minimally invasive types of hysterectomy, is likely to be tailored to the indications for surgery and physicians' experience with the available techniques.

Disclosure Statement

Dr. Toy is a proctor for Intuitive Surgical, Inc. He reviewed the manuscript but did not take part in data collection or analysis.

No other authors have any financial conflicts of interest.

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