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Comparison of Robotic and Laparoscopic Hysterectomy for Benign Gynecologic Disease

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Abstract

Objective—Utilization of robotically assisted hysterectomy for benign gynecologic conditions is increasing. Using the most recent, available nationwide data, we examined clinical outcomes, safety, and cost of robotic compared to laparoscopic hysterectomy.

Methods—Women undergoing robotic or laparoscopic hysterectomy for benign disease were identified from the United States 2009 and 2010 Nationwide Inpatient Sample. Propensity scores derived from a logistic regression model were used to assemble matched cohorts of patients undergoing robotic and laparoscopic hysterectomy. Differences in in-hospital complications, hospital length of stay, and hospital charges were assessed between the matched groups.

Results—Of the 804,551 hysterectomies for benign conditions performed in 2009 and 2010, 20.6% were laparoscopic and 5.1% robotically-assisted. Among minimally invasive hysterectomies, the use of robotic hysterectomy increased from 9.5% to 13.6% (P=0.002). In a propensity-matched analysis, the overall complication rates were similar between robotic and laparoscopic hysterectomy (8.80 vs. 8.85%; relative risk [RR], 0.99; 95% confidence interval [CI], 0.89 to 1.09; *P*=0.910). There was a lower incidence of blood transfusions in robotic cases (2.1% vs. 3.1%; *P*<0.001, but patients undergoing robotic hysterectomy were more likely to experience postoperative pneumonia (RR= 2.2; 95% CI, 1.24 to 3.78; *P*=0.005). The median cost of hospital care was $9788 (IQR, $7105-$12780) for RH and $7299 (IQR, $5650-$9583) for LH (*P*<0.001. Hospital costs were on average $2489 (95% CI, $2313 to $2664) higher for patients undergoing robotic hysterectomy.

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Conclusion—The utilization of robotic hysterectomy has increased. Perioperative outcomes are similar between laparoscopic and robotic hysterectomy, but robotic cases cost substantially more.

Introduction

Hysterectomy is one the most common major surgical procedures performed in the United States. With over 500,000 cases performed each year, it accounts for more than $5 billion in healthcare spending (1, 2). Traditionally, hysterectomy has been performed abdominally through a laparotomy incision, vaginally, or laparoscopically. Over the past 25 years, technological advances, coupled with changes in practice patterns regarding route of hysterectomy, have led to an increase in minimally invasive options (1, 3, 4).

Advantages of laparoscopic hysterectomy over open abdominal hysterectomy are decreased postoperative pain, shorter hospital stay, and quicker return to daily activities (3, 4). However, some of the challenges to widespread adoption of the laparoscopic approach are the steep learning curve, longer operating times, as well as counter-intuitive hand movement, two-dimensional visualization and limited instrument mobility (5). Robotic-assisted laparoscopic surgery was developed to overcome some of the limiting aspects of conventional laparoscopy. Advantages of the robotic platform include better ergonomics, wider range of motion and 3-dimensional stereo vision (5). This platform has grown increasingly popular , withgynecologic surgeries currently composing about half of all procedures using the Intuitive DaVinci System (6,7).

The rapid uptake of robotic-assisted hysterectomy (RH) for benign gynecologic disease has expanded the options for achieving a minimally invasive hysterectomy; however, the available data about its comparative effectiveness has been limited to observational studies and two randomized trials which in total include 148 subjects (8-16). These studies have demonstrated similar outcomes between RH and conventional laparoscopic hysterectomy (LH) with higher costs for robotic-assisted procedures. However, the majority of the published data from observational studies and clinical trials come from highly experienced surgical centers. These results may not be generalizable as the procedure diffuses into wider practice.

Using a nationwide sample, a recent study by Wright, et al showed similar results as the previous observational studies (16). Using an all-payer representative nationwide population-based database, we examined specific perioperative outcomes and costs of RH compared to LH. As the largest all-payer inpatient database, the NIS captures 20% of all hospital admissions in the United States, allowing us to examine if there is an improvement in perioperative outcomes when utilizing robotic technology for benign hysterectomy.

Materials and Methods

Patient population and data source

The population of patients for the study consisted of women older than 18 years of age undergoing conventional or robotic laparoscopic hysterectomy for treatment of benign uterine disease in the United States. Data were obtained from the 2009 and 2010 Nationwide

Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP) of the Agency for Health Care Research and Quality (AHRQ) (17). The NIS is the largest all-payer inpatient database in the United States. It represents a 20% stratified sample of inpatient discharges from non-federal academic, community, and acute care hospitals. Over 1,000 hospitals are included in the NIS each year. The sampling strategy of the NIS allows inclusion in the database of all discharge data from hospitals selected for the survey in a specific year. A total of 44 and 45 states contributed to NIS data in 2009 and 2010, respectively. The study was limited to the years 2009 and 2010 because a specific International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure code useful to identify robotic-assisted hysterectomy was first introduced in 2008. However, data from the 2008 NIS dataset was not included in the analysis to avoid the effect of under-coding of the newly introduced procedure code in 2008. As the NIS datasets consist of publically available and de-identified data, the study was determined to be exempt from review by the University of Texas Southwestern Medical Center Institutional Review Board.

Identification of patients undergoing laparoscopic hysterectomy for benign disease—Hospital discharges with ICD-9-CM procedure codes for laparoscopic supracervical hysterectomy (68.31), laparoscopic total abdominal hysterectomy (68.41, 68.61), and laparoscopic assisted vaginal hysterectomy (68.51) were identified from the NIS datasets. Discharges with the ICD-9-CM procedure code for “laparoscopic robotic assisted procedure” (17.42 and 17.44) in combination with any of the hysterectomy codes were categorized as having undergone a RH. Otherwise, cases were categorized as LH. Patients with ICD-9-CM diagnostic codes for malignant neoplasm of female genital organs (179 and 180.0 – 184.9) were excluded from the analyses.

Identification of covariates—Twenty-six comorbidity variables were created from the up to 25 ICD-9-CM diagnosis codes present in each discharge record. The AHRQ Comorbidity Software, a family of tools developed as part of the HCUP, was used to create the comorbidity variables. The software allows identification of comorbidities, excluding conditions that may be complications of the admission or procedure, or that may be related to the principal diagnosis (18). In addition, the Charlson-Deyo comorbidity index was calculated for each patient based on the ICD-9-CM diagnosis codes available from the database. The Charlson comorbidity index is a validated measure for use with administrative data that correlates with in-hospital morbidity and mortality after surgical procedures (19). The index is the composite of 22 comorbidities, which are assigned a score of 1, 2, 3, or 6 depending on the respective associated postoperative risk. Hospital characteristics such as teaching status of hospital, bed size, and location of hospital (urban vs. rural), as well as demographic characteristics of patients (age, race/ethnicity, and type of healthcare insurance), were obtained directly from separate variables available in the NIS. A hospital was defined as a teaching hospitals if it had an approved residency program, was a member of the Council of Teaching Hospitals or had a ratio of full-time equivalent interns and residents to beds of 0.25 or higher. Socioeconomic status was assessed using the quartile classification of the estimated median household income of residents in the patient's ZIP Code. This information is provided directly in the NIS database. Because practice patterns have been shown to vary substantially by geographic region in the United States (20, 21), the hospital's census region (Northeast, Midwest or North Central, South, and West) was also identified and incorporated into the analyses.

Given that the comparative rate of outcomes between RH and LH can be affected by the surgical diagnosis and performance of concomitant procedures during hysterectomy, additional variables were created to account for these factors. ICD-9-CM codes and AHRQ Clinical Classifications Software (CCS) (21) codes were used to define these variables. Surgical diagnoses included endometriosis (CCS code 169); fibroids (CCS code 46); adenomyosis (ICD-9-CM code 617.0); peritoneal adhesions (ICD-9-CM, 568.0,614.6); presence of adnexal mass, inflammation or infection (ICD-9-CM, 220, 221, 620.1, 620.2, 621, 614, 614.1, 614.2, 614.3, 614.4, 614.8); chronic pelvic pain (ICD-9-CM, 625.8, 625.9); and pelvic organ prolapse (CCS code 170), Additional surgical procedures included adnexal surgery (CCS codes 119, 120, 123); repair of pelvic organ prolapse (ICD-9-CM, 705.0, 705.1, 705.2, 705.3, 705.4, 705.5, 707.2, 707.3, 707.4, 707.5, 707.7, 707.8, 707.9, 709.4, 709.5); lysis of peritoneal adhesions (ICD-9-CM, 545.1, 545.9); and procedures to treat endometriosis (ICD-9-CM, 54.4, 68.23, 65.25, 65.29, 66.61, 68.29, 70.32). Any cases identified with the ICD-9 diagnosis code V64.41 (conversion to open surgery) were excluded due to the inability to classify if the case started as either an RH or LH.

Outcome variables—In-hospital mortality, perioperative adverse events, hospital length of stay (LOS), and cost of hospital care were compared between RH and LH. The primary endpoint for the study was the composite of any in-hospital death or any surgical or medical perioperative adverse event. In-hospital death was determined directly from a variable present in the database. In-hospital perioperative adverse events were determined from the diagnostic and procedure ICD-9-CM codes present in the NIS. Surgical adverse events included accidental puncture or laceration of pelvic or abdominal organs, foreign body left during procedure, iatrogenic pneumothorax, surgical wound disruption, postoperative hemorrhage or hematoma, and blood transfusion. Medical adverse events included postoperative stroke, respiratory failure, endotracheal intubation, pneumonia, atelectasis, pulmonary embolism or deep vein thrombosis, myocardial infarction, acute renal failure, ileus, urinary tract infection, urinary retention, fever, and sepsis.

The cost of hospital services was estimated by applying the HCUP Cost-to-Charge Ratio Files to reported hospital charges. The NIS only provides information on hospital charges, which usually overestimates the actual cost of hospital care. However, the use of Cost-to Charge Ratio Files allows the conversion of charge data to cost estimates. The Cost-to-Charge files are a validated tool to estimate hospital costs, and are constructed using all-payer, inpatient cost and charge information from the detailed reports by hospitals to the Centers for Medicare and Medicaid Services (23). Hospital charges were adjusted for inflation using the Consumer Price Index and converted to 2010 U.S. dollars.

Statistical Analysis

Univariate analyses were performed to compare patients undergoing RH or LH regarding baseline characteristics. Weighted analyses taking into account the NIS survey design were conducted on the non-matched cohort of hospital discharges using the SURVEY FREQ, SURVEY REG, and SURVEY MEANS procedures of the SAS software. Continuous variables are summarized as means ± standard deviations, except for heavily skewed distributions, which are reported as medians and interquartile ranges. Discrete variables are presented as frequencies and group percentages. Propensity scores (PS) derived from a logistic regression model (constructed to estimate the conditional probability for receiving a RH) were used to assemble a 1:1 matched cohort of patients undergoing RH or LH. Covariates in the model for PS included demographics, comorbidities, surgical diagnoses, type of hysterectomy (total vs. supracervical), concomitant surgical procedures, type of healthcare insurance, and hospital characteristics. Propensity matching was done using a greedy 8 to 1 digit-matching algorithm technique. Under this algorithm, each patient undergoing RH was matched to a patient undergoing LH whose propensity score was as close as possible to that of the RH patient starting at the eighth digit of precision. When all matches at the eighth digit were exhausted, RH patients were then matched to LH patients on 7 digits of the propensity score, and the algorithm proceeded sequentially until finding a LH match for each RH patient or until the one digit of propensity score precision matching was reached. Absolute standardized differences were calculated to assess post-match balance between the propensity-matched groups. An absolute standardized difference equal to or smaller than 10% indicates appropriate balance of a baseline covariate between the groups (24). Differences in the composite primary endpoint, as well as in in-hospital mortality and incidence of perioperative surgical and medical adverse events, were assessed between the matched groups using McNemar's tests. Relative risks with 95% confidence intervals were calculated for each outcome. As hospital length of stay (LOS) and costs of hospital care were not normally distributed, these variables were described as medians and interquartile ranges and compared between the matched groups using Wilcoxon signed-rank tests. Given the right-skewed distribution of the data, differences in hospital cost of care between RH and LH were estimated using quantile regression analyses, as described previously (24). Quantile regression results in estimates approximating the median (or other quantile) of the response variable, and because it makes no distributional assumption about the error term in the model, this technique offers considerable robustness when the distributional assumptions of conditional mean regression are not met (26). All statistical tests were 2-tailed. A P value of 0.005 (adjusting for multiple testing) was considered statistically significant. SAS 9.2 software (Cary, NC) was used for all the analyses.

Results

A total of 804,551 hysterectomies for benign conditions were performed in the United States during 2009 and 2010. In 2009, there were 242,428 (56.68%) abdominal hysterectomies (AH), 81,446 (19.04%) TVH, 86,253 (20.17%) LH, and 17,587 (4.11%) RH. In 2010, there were 202,262 (53.67%) AH71,793 (19.05%) TVH, 79,128 (21.0%) LH, and 23,654 (6.28%) RH procedures. The total number of hysterectomies decreased from 427,714 to 376,837, and in relation to all hysterectomies over the time period, the rate of AH decreased 3%, LH increased 1%, RH increased 2%, while the rate of TVH remained unchanged. The use of RH among minimally invasive hysterectomies increased from 9.5% in 2009 to 13.6% in 2010 (P=0.002). LH and RH represented, respectively, 20.6% and 5.1% of the 804,551 hysterectomies performed in the US in 2009 and 2010.Table 1 describes the baseline clinical, demographic, and hospital characteristics of patients undergoing RH and LH in 2009 to 2010 in the US in the non-matched cohort. Patients undergoing RH were on an average older and had higher comorbidity scores than patients undergoing LH. The weighted data before matching revealed that patients undergoing RH were more likely to have Medicare or private insurance, to live in ZIP code areas of higher median household income, and to have the procedure performed in large, urban, and teaching hospitals. RH patients were also more likely to have higher prevalence of chronic conditions like hypertension, congestive heart failure, diabetes mellitus, chronic renal failure, and obesity. Similarly, a diagnosis of fibroids or peritoneal adhesions was more frequent among RH patients. In contrast, LH patients were more likely to have diagnoses of endometriosis, adenomyosis, pelvic organ prolapse, and chronic pelvic pain. In addition, LH was used more often to perform supracervical hysterectomies (21.9% vs. 13.1%) while RH was used more frequently to perform total hysterectomies (86.9 vs. 78.1%).

The propensity-matching algorithm produced a cohort of 7,788 patients undergoing RH and 7,788 patients undergoing LH for benign gynecologic conditions, well balanced on baseline characteristics (Table 2). The rate of in-hospital mortality was very low for both RH and LH and not statistically different between the groups (0.03% vs. 0%, respectively; P=0.249). Similarly, the incidence of the composite outcome of death, surgical, or medical complications was similar for both groups (8.80 vs. 8.85%; relative risk [RR] for RH, 0.99; 95% confidence interval [CI], 0.89 to 1.09; *P*=0.910) (Table 3). Although RH patients had significantly lower incidence of blood transfusions than LH patients (2.1% vs. 3.1%, respectively; *P*<0.001, in general, the rate of surgical complications was comparable between the groups (4.67% vs. 5.33%; *P*=0.060). The rate of medical postoperative adverse events was also similar between RH and LH (4.78% vs. 4.35%, respectively; *P*=0.205). However, RH patients were about two times more likely to experience postoperative pneumonia (RR= 2.2; 95% CI, 1.24 to 3.78; *P*=0.005) than LH patients, and there was a trend to increased postoperative endotracheal intubations (RR, 1.84; 95% CI, 0.94 to 3.62;, *P*=0.07) in the RH group.

Hospital length of stay was, on average, not significantly different between the groups. For both RH and LH the median length of stay (LOS) was one day and 75% of the patients were discharged from the hospital in two days or less. Finally, the median inflation-adjusted cost of hospital care was $9788 (IQR, $7105 - $12780) for RH and $7299 (IQR, $5650 - $9583) for LH (*P*<0.001. Hospital costs were on average $2489 (95% CI, $2313 to $2664) higher for patients undergoing RH compared to those undergoing LH.

Discussion

This nationwide, population-based analysis demonstrates that 25% of all hysterectomies for benign disease were performed either laparoscopically or robotically-assisted, with one RH performed for every four LH. From 2009 to 2010, the use of RH increased from 4.1% to 6.3% of all hysterectomies, while abdominal hysterectomy rates fell and vaginal hysterectomy rates remained unchanged. Compared to LH, RH is being performed more frequently in patients with higher incomes and who have private insurance, as well as in larger, urban, teaching hospitals. Notably RH patients were older, and had more comorbidities.

In our comparison of 7778 closely matched patients , in-hospital perioperative complication rates were similar between the two procedures. Our analysis demonstrated significantly more blood transfusions in the LH group, though hemorrhage and hematoma rates were similar. These findings contrast with previous randomized trials that found no difference in blood loss between the two groups (13, 14). The RH group experienced more pulmonary complications with a higher incidence of postoperative pneumonia. Possibly related to this was a trend towards more postoperative endotracheal intubations. Most studies have consistently demonstrated longer operating times for RH (ranging from 26 to 72 minutes longer) (9-13, 15) and Pasic et al found a similar trend towards pulmonary adverse events (15). We propose that the increased need for postoperative intubation may be due to airway edema and basal atelectasis that may develop during lengthy procedures in steep Trendelenburg positioning, which may make tracheal extubation difficult.

Affirming the finding that RH cases cost more, we found that the total cost estimates for RH are consistently higher by $2489 per case (12, 15, 16). Unfortunately, the greater costs associated with RH were not reflected in improvement in outcomes.

We recognize several limitations of our analysis. The Nationwide Inpatient Sample is a large database that receives diagnosis and procedural codes from 45 state databases. Therefore, underestimation of complication rates, and errors in classification of predictor variables are possible, though it is likely that such systematic errors would be consistent across groups. Additionally, the NIS does not include factors such as patient body mass index, uterine weight, operating time, and physician characteristics such as specialty training or surgeon experience. Though we used conservative matching criteria, it is possible that the two groups may not be matched with regards to such unmeasured characteristics. We were also unable to factor capital costs, annual service contract charges, and depreciation of the robot into our analyses. Use of the AHRQ cost-to-charge converted cost values allows estimates of the entire hospital stay rather than specific line-item charges. Physician charges, indirect costs, societal costs, and secondary charges associated with subsequent hospital stays or ambulatory visits are, therefore, unavailable from the NIS.

A strength of our study is the use of the largest publicly available, all-payer inpatient care database in the United States, which allows us to analyze large cohorts of procedures that would be difficult to assess in a clinical trial. While Wright et al examined data from 441 hospitals, our analysis consists of LH and RH procedures performed in 590 hospitals in 2009, and 612 hospitals in 2010. The consistency of the overall findings between these two studies provides a strengthening of the limited available comparisons between LH and RH and the representativeness of the hospitals sampled allows for generalizability of these results. Complications such as pneumonia and need for blood transfusion may not have been recognized previously because of their rarity which would require assessment of large numbers of cases. By aggregating two years of data we were able to create matched cohorts which are large enough to demonstrate these clinically significant findings. As with any new technology, we may find different results as the learning curve progresses, training programs formalize technical skills training, and institutions become more stringent about credentialing of surgeons.

Our findings augment the existing data and may serve to determine sample sizes of future clinical trials appraising the comparative-effectiveness of RH and identify potential sub-groups of patients who may benefit from the utilization of the robotic platform (27). Furthermore, we hope to have highlighted hypothesis-generating differences in clinical outcomes, including pulmonary complications.

In conclusion, the use of robotics for benign gynecologic conditions increased from 2009 to 2010, despite higher associated charges and similar perioperative outcomes to LH. As this technology evolves and diffuses into practice, we should continue to examine the comparative effectiveness of robotic hysterectomy and critically appraise its role in the performance of benign hysterectomies.

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Table 1

Baseline Characteristics of Patients Undergoing Robotic or Laparoscopic Hysterectomy, United States 2009-2010, Unmatched-Weighted Data

Characteristic	Robotic Hysterectomy, n=41,241		Laparoscopic Hysterectomy, n =165,381		*P*
Year, n (%)					0.002
2009	17,587	(42.6)	86,253	(52.2)	
2010	23,654	(57.4)	79,128	(47.8)	
Age, years, mean (SD)	47.3	(23.3)	44.8	(21.7)	<0.001
Charlson comorbidity index					<0.001
0	32,673	(79.2)	137,384	(83.1)	
1-2	7,998	(19.4)	26,706	(16.1)	
>2	570	(1.4)	1,290	(0.8)	
Race/Ethnicity, n (%)					0.390
Non-Hispanic White	26,784	(64.9)	103,630	(62.7)	
African American	4,333	(10.5)	15,983	(9.6)	
Hispanic	3,074	(7.5)	14,129	(8.5)	
Other/Unknown	7,050	(17.1)	31,638	(19.1)	
Source of payment, n (%)					<0.001
Medicare	4,250	(10.3)	12,074	(7.3)	
Medicaid	3,153	(7.6)	17,581	(10.7)	
Private Insurance	31,885	(77.4)	123,481	(74.9)	
Other	1,922	(4.6)	11,679	(7.1)	
Median household income for patient's zip code, n (%)					<0.001
1 - 40,999	7,109	(17.5)	36,414	(22.5)	
41,000 - 50,999	9,134	(22.5)	40,224	(24.8)	
51,000 - 66,999	11,225	(27.7)	43,621	(26.9)	
67,000+	13,103	(32.3)	41,556	(25.7)	
Hospital bed size, n (%)					<0.001
Small	2,761	(6.8)	23,115	(14.2)	
Medium	8,527	(21.1)	45,397	(27.8)	

Characteristic	Robotic Hysterectomy, n=41,241		Laparoscopic Hysterectomy, n =165,381		***P***
Large	29,190	(72.1)	94,754	(58.0)	
Urban location of hospital, n (%)	39,676	(98.0)	141,461	(86.6)	<0.001
Teaching status of hospital, n (%)	22,232	(54.9)	68,540	(42.0)	0.005
Hospital geographic region, n (%)					0.365
Northeast	8,794	(21.3)	27,874	(16.8)	
Midwest	9,802	(23.8)	33,247	(20.1)	
South	13,031	(31.6)	63,104	(38.2)	
West	9,614	(23.3)	41,156	(24.9)	
Hypertension, n (%)	10,340	(25.1)	31,865	(19.3)	<0.001
Chronic lung disease, n (%)	4,214	(10.2)	15,600	(9.4)	0.093
Congestive heart failure, n (%)	166	(0.4)	414	(0.2)	0.036
Diabetes mellitus, n (%)	3,084	(7.5)	8,776	(5.3)	<0.001
Chronic renal failure, n (%)	198	(0.5)	508	(0.3)	0.018
Obesity, n (%)	5,107	(12.4)	14,805	(8.9)	<0.001
Endometriosis, n (%)	8,768	(21.3)	43,983	(26.6)	<0.001
Adenomyosis, n (%)	5,568	(13.5)	27,668	(16.7)	0.002
Leiomyomas, n (%)	20,362	(49.4)	76,766	(46.4)	0.013
Pelviperitoneal adhesions, n (%)	8,721	(21.1)	27,796	(16.8)	<0.001
Adnexal mass, n (%)	7,816	(18.9)	29,931	(18.1)	0.239
Pelvic organ prolapse, n (%)	5,295	(12.8)	28,134	(17.0)	0.012
Chronic pelvic pain, n (%)	5,423	(13.1)	27,634	(16.7)	<0.001
Concurrent adnexal procedure, n (%)	24,814	(60.2)	95,313	(57.6)	0.067
Concurrent pelvic prolapse repair, n (%)	4,402	(10.7)	19,406	(11.7)	0.505
Concurrent treatment endometriosis, n (%)	1,693	(4.1)	7,293	(4.4)	0.409
Type of hysterectomy, n (%)					<0.001
Total	35,843	(86.9)	129,197	(78.1)	
Supracervical	5,398	(13.1)	36,184	(21.9)	

Table 2

Baseline Characteristics of Patients Undergoing Robotic or Laparoscopic Hysterectomy in the United States, 2009-2010, Propensity-Matched Sample

Characteristic	Robotic Hysterectomy n=7,788		Laparoscopic Hysterectomy n=7,788		Standardize d Difference	*P*
Year, n (%)						0.795
2009	3,321	(42.6)	3,337	(42.8)	-0.47	
2010	4,467	(57.4)	4,451	(57.2)	0.35	
Age, years, mean (SD)	47.2	(10.2)	47.5	(10.3)	-1.03	0.064
Charlson index categories, n (%)						0.509
0	6,189	(79.5)	6,160	(79.1)	0.51	
1-2	1,494	(19.2)	1,535	(19.7)	-2.64	
>2	105	(1.3)	93	(1.2)	8.44	
Race/ethnicity, n (%)						0.703
Non-Hispanic White	5,021	(64.5)	4,973	(63.9)	0.94	
African American	796	(10.2)	822	(10.5)	-3.05	
Hispanic	594	(7.6)	624	(8.0)	-5.49	
Other/unknown	1,377	(17.7)	1,369	(17.6)	0.58	
Source of payment, n (%)						0.513
Medicare	787	(10.1)	829	(10.6)	-5.08	
Medicaid	592	(7.6)	600	(7.7)	-1.40	
Private Insurance	6,046	(77.6)	5,973	(76.7)	1.17	
Other	363	(4.7)	386	(5.0)	-6.94	
Median household income for patient's zip code, n (%)						0.756
1 - 40,999	1,373	(17.6)	1,345	(17.3)	1.77	
41,000 - 50,999	1,763	(22.6)	1,725	(22.2)	1.83	
51,000 - 66,999	2,136	(27.5)	2,160	(27.7)	-0.74	
67,000+	2,516	(32.3)	2,558	(32.8)	-1.56	
Hospital bed size, n (%)						0.423
Small	559	(7.2)	580	(7.4)	-2.95	
Medium	1,655	(21.2)	1,708	(21.9)	-3.33	

Characteristic	Robotic Hysterectomy n=7,788		Laparoscopic Hysterectomy n=7,788		Standardize d Difference	*P*
Large	5,574	(71.6)	5,500	(70.7)	1.27	
Urban location of hospital, n (%)	7,613	(97.7)	7,642	(98.1)	-0.41	0.101
Teaching status of hospital, n (%)	4,213	(54.1)	4,254	(54.6)	-0.93	0.509
Hospital geographic region, n (%)						0.337
Northeast	1,590	(20.4)	1,634	(21.0)	-2.97	
Midwest	1,812	(23.3)	1,729	(22.2)	4.94	
South	2,464	(31.6)	2,448	(31.4)	0.65	
West	1,922	(24.7)	1,977	(25.4)	-2.85	
Hypertension, n (%)	1,916	(24.6)	1,943	(24.9)	-1.24	0.470
Chronic lung disease, n (%)	795	(10.2)	845	(10.8)	-6.00	0.222
Congestive heart failure, n (%)	27	(0.35)	29	(0.37)	-4.17	0.788
Diabetes mellitus, n (%)	567	(7.3)	587	(7.5)	-2.91	0.540
Chronic renal failure, n (%)	37	(0.5)	30	(0.4)	8.01	0.391
Obesity, n (%)	958	(12.3)	971	(12.5)	-1.68	0.751
Endometriosis, n (%)	1,668	(21.4)	1,597	(20.5)	4.40	0.162
Adenomyosis, n (%)	1,067	(13.7)	1,052	(13.5)	1.53	0.725
Fibroids, n (%)	3,862	(49.6)	3,852	(49.5)	0.20	0.872
Pelviperitoneal adhesions, n (%)	1,600	(20.5)	1,651	(20.2)	1.51	0.314
Adnexal mass, n (%)	1,465	(18.8)	1,363	(17.5)	7.36	0.053
Pelvic organ prolapse, n (%)	990	(12.7)	1,048	(13.4)	-5.58	0.168
Chronic pelvic pain, n (%)	992	(12.74)	988	(12.69)	0.41	0.923
Concurrent adnexal procedure, n (%)	4,656	(59.8)	4,657	(59.8)	0.00	0.987
Concurrent pelvic prolapse repair, n (%)	825	(10.6)	769	(9.9)	7.18	0.139
Concurrent treatment endometriosis, n (%)	314	(4.0)	293	(3.8)	5.94	0.384
Type of hysterectomy, n (%)						0.360
Total	6,756	(86.7)	6,717	(86.2)	0.58	
Supracervical	1,032	(13.2)	1,031	(13.7)	-3.86	

SD, standard deviation.

Table 3

Outcomes in Patients Undergoing Robotic or Laparoscopic Hysterectomy, United States, 2009-2010, Propensity-Matched Sample

Characteristic	HyRobotic sterectomy n=7,788		Laparoscopic Hysterectomy n =7,788		Relative Risk (95% CI)	*P*
	n	%	n	%		
Any complication	685	8.80	689	8.85	0.99 (0.89 – 1.09)	0.910
In-hospital death	*	0.03	0	0.00	N/A	0.249
Surgical complications	364	4.67	415	5.33	0.87 (0.76 – 1.01)	0.060
Foreign body left during procedure	*	0.01	*	0.05	0.25 (0.02–2.23)	0.374
Iatrogenic Pneumothorax	*	0.03	0	0.00	N/A	0.500
Postoperative hemorrhage/hematoma	*	0.13	17	0.22	0.58 (0.27 – 1.28)	0.177
Accidental Intraoperative laceration	203	2.61	171	2.20	1.18 (0.97 – 1.45)	0.093
Wound disruption	0	0.00	0	0.00	N/A	1.000
Blood transfusion	165	2.12	244	3.13	0.67 (0.55 – 0.82)	<0.001
Postoperative medical complications	372	4.78	339	4.35	1.09 (0.95 – 1.26)	0.205
Respiratory failure	11	0.14	*	0.13	1.10 (0.46 – 2.58)	0.827
Pulmonary embolism or deep vein thrombosis	*	0.13	15	0.19	0.66 (0.29 – 1.48)	0.316
Sepsis	*	0.05	*	0.01	4.0 (0.44 -35.7)	0.374
Acute myocardial infarction	*	0.04	*	0.01	3.0 (0.31 – 28.8)	0.625
Acute renal failure	19	0.24	15	0.19	1.26 (0.64 – 2.49)	0.492
Stroke	*	0.03	*	0.01	2.0 (0.18 – 22.05)	1.000
Ileus	103	1.32	82	1.05	1.25 (0.94 – 1.67)	0.120
Tracheal intubation	24	0.31	13	0.17	1.84 (0.94 – 3.62)	0.070
Pneumonia	39	0.50	18	0.23	2.2 (1.24 – 3.78)	0.005
Atelectasis	77	0.99	67	0.86	1.1 (0.82 – 1.59)	0.402
Fever	20	0.16	14	0.18	1.4 (0.72 – 2.82)	0.303
Urinary tract infection	48	0.62	65	0.83	0.7 (0.50 – 1.07)	0.108
Urinary retention	90	1.16	106	1.36	0.8 (0.64 – 1.12)	0.250
Length of hospital stay (median, IQR)	1	1-2	1	1-2	0 (0.00 – 0.00)	0.939
Total hospital costs, $ (median, IQR)	978 8	7105 -12780	729 9	5650 -9583	2489 (2313 – 2664)	<0.001

N/A, not applicable; IQR, interquartile range.

*Number of observations in the cell is less than or equal to 10. Actual numbers not published to be compliant with the Data Use Agreement for the Nationwide Databases from the Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality (http://www.hcup-us.ahrq.gov/team/NationwideDUA.jsp).