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Costs and Outcomes of Abdominal, Vaginal, Laparoscopic and Robotic Hysterectomies

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ABSTRACT

Background and Objectives: To estimate the incidence of operative complications and compare operative cost and overall cost of different methods of benign hysterectomy including abdominal, vaginal, laparoscopic, and robotic techniques.

Methods: We performed a retrospective cohort analysis (Canadian Task Force classification II-2) of all patients who underwent a hysterectomy for benign reasons in 2009 at a single urban academic tertiary care center using the χ^2 test and Student t test. A multivariate regression analysis was also performed for predictors of costs. Cost data were gathered from the hospital's billing system; the remainder of data was extracted from patient's medical records.

Results: In 2009, 688 patients underwent a benign hysterectomy; 185 (26.9%) hysterectomies were abdominal, 135 (19.6%) vaginal, 352 (51.5%) laparoscopic, and 14 (2.0%) robotic. The rate of intraoperative complication was 1.7% for abdominal, 0.8% for vaginal, 0.3% for laparoscopic, and 0 for robotic. Mean total patient costs were $43,622 for abdominal, $31,934 for vaginal, $38,312 for laparoscopic, and $49,526 for robotic hysterectomies. Costs were significantly influenced by method of hysterectomy, operative time, and length of stay.

Conclusion: Though complication rates did not vary significantly among minimally invasive methods of hysterectomy, patient costs were significantly influenced by the method of hysterectomy.

Key Words: Cost-minimization analysis, Hysterectomy, Surgical outcomes.

INTRODUCTION

Hysterectomy is the most common gynecologic surgical procedure performed in the United States with approximately 600,000 cases per year, accounting for over $5 billion health care dollars.[1] In the United States (US), 20% of women will have had a hysterectomy by the age of 40[2] increasing to 33% by the age of 65,[3] and 43% by the age of 85,[4] making it the second most common surgery American women undergo.

Analysis of US surgical data showed that abdominal hysterectomy is performed in 66% of cases, vaginal hysterectomy in 22% of cases, and laparoscopic hysterectomy in 12% of cases.[5] Professional organizations as well as research institutes have issued guidelines in support of minimally invasive procedures, vaginal hysterectomy in particular, when choosing the method of hysterectomy.[6,7] Despite these recommendations and evidence of superior health and economic outcomes, most hysterectomies continue to be performed via a laparotomy.

Requirements for savings in the health system accompanied by a limited budget available for health care and increased demands on clinical excellence have led to the need to evaluate cost and effectiveness of treatments. With the introduction of new technology for hysterectomy as well as the push for shorter hospital stays, new data are needed to estimate the most cost-effective method of hysterectomy. The main objectives of our study are to estimate the incidence of operative complications and compare operative cost and overall cost of different methods of benign hysterectomy, including abdominal, vaginal, laparoscopic, and robotic techniques.

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METHODS

Data Collection

A retrospective cohort study was undertaken. All gynecological cases performed at Brigham and Women's Hospital from January 1, 2009 to December 31, 2009 were retrospectively obtained from operating room (OR) case records. All indications were collected, but only patients with benign indications were included in this study. Information was abstracted from electronic medical records, which were reviewed for each patient. The information obtained from the charts included the medical record number, date of birth, age, insurance carrier, body mass index (BMI), parity, preoperative and postoperative diagnoses, hysterectomy performed, concomitant procedures, pathology report, length of stay, surgeon, assistant type (attending, fellow, or resident), estimated blood loss (EBL), indication for surgery, prior abdominal surgery, uterine weight, postoperative complications, postoperative admission, intraoperative complications, conversions, and OR time. We collected in-room to out-of-room times instead of the commonly reported skin-to-skin time, because there are properties inherent to certain patients that make them more difficult to intubate, position, or undergo uterine manipulator placement, and different methods require different setups prior to skin incision, which contributes to the utilization of an OR. Intraoperative complications were defined as bowel, urological, or vascular injuries, or EBL > 1000.[8] Hysterectomies were divided by method and maintained in intention-to-treat categories. For example, all laparoscopic hysterectomies that were converted to open were still analyzed as the laparoscopic method. Hospital accounting ledgers were used to obtain operative and total encounter hospital costs as well as operative and total encounter billing charges. The study was reviewed and approved by the Brigham and Women's Internal Review Board. Statistical descriptions and analyses were performed using SAS software (SAS Institute Inc., Cary, NC; Version 9.0). Associations were tested using χ^2 for categorical variables and Student t tests for continuous variables where appropriate. A multivariate linear regression analysis was also performed for the variables under study as they relate to the outcomes and costs as listed. A P value < 0.05 was considered significant for all variables.

Cost Approximation

Costs were categorized as cost to the hospital and costs to the patient (patient charges). We defined patient costs as the actual bill sent to the patient or insurance company, because this is what the patient or insurance company actually sees. Costs were also divided into OR-specific costs and total costs for the hysterectomy encounter. OR costs were obtained from hospital accounting ledgers and include direct costs (equipment cost and OR time) and indirect costs in 5 categories (day surgery, ambulatory procedure room, nursing, recovery room, non-nursing). Cost based on OR time is calculated according to a fee schedule that bills in 15-min increments. The fee schedule is based on a combination of labor, supplies, and fixed equipment for an operating room and is adjusted every calendar year. Equipment cost includes what the hospital pays for all disposables, and the depreciation costs of nondisposables are itemized for each case. The cost of the equipment is then multiplied by a graduated fee to create a patient cost. Robot amortization and yearly maintenance are accounted for with a flat fee for every robot case that is adjusted every calendar year. Total encounter costs include direct (labor, supplies, fixed equipment) and indirect costs (cost of depreciation per square foot of unit) related to the encounter. Hospital OR and encounter costs are what the hospital estimates it spent for the patient's OR and total encounter. Reimbursements vary considerably in the United States depending on the multitude of individually negotiated agreements between public and private payer organizations and therefore were not analyzed.

RESULTS

The study included 1079 women who underwent hysterectomy by any method. Fourteen cases listed as laparoscopic-assisted vaginal hysterectomies (LAVH) were excluded, because they represent the combination of 2 procedures; 375 cases were excluded for a diagnosis of cancer; and 2 cases were excluded for incomplete billing information. In total, 688 patients were included in our analysis. The cases were performed by 49 different gynecological surgeons in a gynecology-specific OR pod with a single group of residents and fellows. Our operating room is divided into pods by specialty, so all supervising anesthesiologists, circulating nurses, and scrub technicians were familiar with gynecologic procedures. A specific team of gynecology and robotic-trained scrub technicians and circulating nurses performed all of the robotic cases. All patients were cared for postoperatively by a single group of nurses on a gynecology women-only unit in our institution. Patient characteristics and indications are listed in **Table 1**. The most common indications were fibroids (n = 316, 45.9%), bleeding (n = 247, 35.9%), prolapse (n = 101, 14.7%), and endometriosis (n = 84,

Table 1.
Patient Demographics (n=581)

	Abdominal	Vaginal	Laparoscopic	Robotic
Total[a]	185 (26.89)	135 (19.62)	354 (51.45)	14 (2.03)
Age[b] (years)	48.42 (9.15)	55.83 (12.55)	46.86 (7.82)	47.93 (10.41)
BMI[b] (kg/m$^{2)}$	30.03 (8.13)	26.93 (4.22)	28.75 (6.84)	35.56 (13.4)
Uterine weight[2] (grams)	598.94 (693.45)	99.63 (68.33)	248.84 (222.35)	144.79 (89.44)
Prior laparotomy[a]	67 (41.61)	29 (27.62)	137 (45.07)	6 (54.55)
Prior laparoscopy[a]	34 (21.66)	28 (25.45)	94 (31.23)	6 (50.00)
Adhesions[a]	62 (33.51)	3 (2.24)	83 (23.65)	11 (78.57)
Indications (%)				
Leiomyomas	60	8.15	54.67	7.14
Bleeding	29.19	26.67	43.6	21.43
Endometriosis	6.49	.74	4.52	21.43
Pain	8.11	5.19	16.38	28.57
Prolapse	1.62	66.67	2.26	0

[a]N and percentage (chi-squared test, with 'Abdominal' as reference group).
[b]Mean and standard deviation (Student *t* test, with 'Abdominal' as reference group).

12.2%). Many patients had more than one indication. The mean BMI was 29.0 (range, 16.2 to 62.3) and mean age was 49 (range, 18 to 85).

Perioperative outcomes are listed in **Table 2**. Operative time was least for vaginal hysterectomy (153 min, 95%CI 143.80–163.54, $P < .001$) and greatest for robotic hysterectomy (253 min, 95%CI 215.16–291.67, $P < .001$). EBL was greater in abdominal hysterectomy than in the other 3 methods (333.76 mL, 95%CI 273.54–393.98, $P < .001$). Also, compared to patients who underwent abdominal hysterectomy, patients who underwent vaginal, laparoscopic, or robotic hysterectomy stayed in the hospital for a lower amount of time, 0.86–1.36 d vs. 2.75 d ($P < .001$). There were 11 conversions to open for a rate of 1.6%. One vaginal hysterectomy was converted to open for large EBL and the inability to safely complete the case. There were no conversions for robotic hysterectomies. This low rate is similar to other reported rates found in the literature.[9] Ten

Table 2.
Perioperative Outcomes and Intraoperative Complications by Type of Hysterectomy

	Abdominal	Vaginal	Laparoscopic	Robotic
Operative Time[a] (min)	182.42, 47.77 (175.49, 189.35)	153.67, 58.00 (143.80, 163.54)	185.47, 65.64 (178.61, 192.34)	253.41, 66.25 (215.16, 291.67)
EBL[a] (mL)	333.76, 410.59 (273.54, 393.98)	143.48, 187.71 (111.17, 175.80)	105.43, 131.06 (91.38, 119.47)	79.62, 52.06 (48.16, 111.08)
Length of Stay[a] (days)	2.75, 1.15 (2.58, 2.91)	1.24, .64 (1.13, 1.35)	.86, .82 (.77–.95)	1.36, .50 (1.07, 1.64)
Conversions[b]	—	1 (.74)	10 (2.82)	0
Organ Injury[b]	2 (1.10)	1 (.75)	1 (.29)	0
EBL >=1000[b] (mL)	3 (1.66)	1 (.75)	1 (.30)	0

[a]Mean, standard deviation (95% Confidence interval), (Student *t* test, with 'Abdominal' as reference group).
[b]N and percentage (chi-squared test, with 'Abdominal' as reference group).

laparoscopic cases were converted to open, 8 because of difficulty with the procedure, one for large EBL, and another for organ injury. Intraoperative complications occurred in 5 abdominal cases, 2 vaginal cases, 2 laparoscopic cases, and no robotic cases. Costs and mean differences in costs between each method are reported and examined for significance in **Table 3**. All patient OR costs were significantly different, with vaginal hysterectomy being the least expensive at $26,690 and robotic hysterectomy being the most expensive at $43,794. The difference in cost between abdominal and robotic hysterectomy became insignificant when we accounted for inpatient stay. Mean total patient costs are $43,622 for abdominal, $31,934 for vaginal, $38,312 for laparoscopic, and $49,526 for robotic hysterectomies. Multivariate regression analyses are listed in **Table 4**. Patient characteristics are defined as BMI, age, prior abdominal surgery (laparoscopy and laparotomy), presence of adhesions, and uterine weight. Operative time had many related factors including type of hysterectomy, length of stay, BMI, uterine weight, and presence of adhesions. Type of hysterectomy, OR time, and presence of adhesions were related to OR costs, while total patient cost was affected by type of hysterectomy, OR time, and length of stay.

DISCUSSION

The present study sought to estimate the differences in cost and complications among different methods of hysterectomy performed for benign reasons. Intraoperative complication rates did not significantly differ between all methods of benign hysterectomy. Because outcomes seem to be similar between methods of benign hysterectomy, it has become increasingly important to take patient costs into account. There are many reasons why a surgeon may perform a particular method of hysterectomy based on patient characteristics, surgeon skill set, and perceived difficulty of the procedure. However, in patients for whom more than one method would be equivalently feasible, we aimed to estimate the relative differences in cost to the patient for each particular method of hysterectomy. In our cohort, vaginal hysterectomy was the least costly method to patients. Laparoscopic hysterectomy was less expensive than abdominal hysterectomy and robotic hysterectomy. Even though abdominal hysterectomy had a longer length of stay, longer OR times made robotic hysterectomy the most expensive method when looking at OR costs and total patient costs.

Our data differ from previously published reports that found abdominal hysterectomy to be the most expensive method of hysterectomy in cancer patients[10]; however, it reflects gynecology literature that finds the robotic method to be the most expensive method for other benign gynecologic procedures including myomectomy[11] and sacrocolpopexy.[12] We theorize that patients who undergo hysterectomy for benign indications are healthier and have a shorter length of stay for abdominal hysterectomy that negates the cost of the longer operative times of robotic hysterectomy.

We analyzed actual patient charges as the cost-basis for the patient costs reported in this paper. The use of billed charges as a cost basis is likely to overestimate the true absolute cost, and therefore the costs we report are higher than other

Table 3.
Mean Costs and Cost Differences by Type of Hysterectomy

	Abd[1]	Vag[1]	Lsc[1]	Rob[1]	Mean Differences (95%CI)					
					A-V	A-L	A-R	V-L	V-R	L-R
Patient OR Cost ($)	31084, 7702.90	26690, 9205	33879, 9791.30	43794, 10609	4394.40, 8368.80	−2795, 9129.70	−12709, 7927.60	−7109, 9633.60	−17104, 9337.60	−9914, 9821.50
					(2530.70, 6258.20)	(−4422, −1168)	(−17043, −8376)	(−9104, −5275)	(−22285, −11922)	(−15177, −4651)
					p<.0001	p=.0003	p<.0001	p<.0001	p<.0001	p=.0002
Total Patient Cost ($)	43622, 17570	31934, 13212	38312, 15050	49526, 10809	11688, 15880	5310.70, 15958	−5904, 17206	−6377, 14567	−17592, 13017	−11215, 14920
					(8151.40, 15225)	(2466.70, 8154.60)	(−15309, 3501.60)	(−9273, −3482)	(−24815, −10369)	(−19209, −3220)
					p<.0001	p=.0005	p=.0779	p<.0001	p<.0001	p=.0061

[a]Mean, standard deviation (Student *t* test, with reference group as specified).

Table 4.
Multivariate Regression Analysis for Patient Costs Under Study

	OR Time Adj R-Sq = .2027; P<.0001			Patient OR Cost Adj. R-Sq=.9098; P<.0001			Patient Total Cost Adj. R-Sq=.7550; P<.0001		
	Coefficient	SE of Coefficient	P-Value	Coefficient	SE of Coefficient	P-Value	Coefficient	SE of Coefficient	P-Value
Intercept	56.969	19.499	.0037	2084.743	1056.647	.0493	1735.809	2551.387	.4967
Type of Hyst	13.224	3.686	.0004	1261.888	200.972	<.0001	2166.931	485.269	<.0001
OR Time	—	—	—	148.146	2.882	<.0001	140.025	6.959	<.0001
Length of Stay	10.981	2.670	<.0001	106.227	147.934	.4732	5666.026	357.203	<.0001
Age	.114	.271	.6746	8.778	14.498	.5453	−4.809	35.008	.8908
BMI	1.930	.367	<.0001	−3.934	20.409	.8477	−33.994	49.281	.4908
Uterine Weight	.0124	.367	.0309	.0343	.3077	.2652	−.079	.743	.2884
Prior Laparotomy	3.349	5.457	.5398	−291.486	292.306	.3194	920.627	705.804	.1930
Prior Laparoscopy	−.153	5.935	.9795	−107.737	317.692	.7347	−832.593	767.100	.2785
Adhesions	21.916	6.373	.0007	768.790	346.830	.0273	−895.937	837.699	.2856

numbers in the literature.[13] Unfortunately, the absolute costs of procedures in the American health care system are opaque and difficult to calculate given the discordance between the cost of providing a service, the amount a patient is charged, and the amount that is reimbursed. Nonetheless, by using hospital charges as the cost-basis, we preserve the internal validity of relative cost differences between patients because they are calculated the same way for each patient in our cohort. Moreover, these hospital charges are itemized and scale more directly with operative time, surgical complications, length of stay, and other probable cost drivers compared to hospital estimates and individually negotiated reimbursement agreements. Interestingly, when we analyzed actual hospital costs according to the hospital's accounting ledger, the total hospital cost for each method of hysterectomy differed by less than $1000. We theorize that estimating inpatient costs directly associated with each patient is difficult, and that hospital costs are shared among patients within a unit equally. This finding displays an example of cost shifting between all patients in a department, an increasing practice in hospitals today. Since all patients in our cohort who underwent hysterectomy were cared for on a single unit, the hospital attributes a similar cost burden to each patient, regardless of method or length of stay. Perhaps the most striking finding of our study was the inaccuracy of using hospital costs when attempting an internal comparison.

Although this study represents a large patient database, it is limited by its retrospective nature with inherent selection bias, as patients with similar indications cannot be randomized to different methods. The data collection itself is subject to measurement bias as a result of inaccurate coding of procedures or errors in data gathering. The variety in concomitant procedures (prolapse repair, bilateral salpingo-oophorectomy) as well as indication (fibroids versus prolapse) represents many confounders that add to heterogeneity of results, and this may limit our final interpretation by diluting an effect that took place in only one subgroup. Our robotic cohort had a low number with only 14 or 2% of cases. Even though all of these cases were performed by experienced minimally invasive surgeons who had completed their learning curve of cases (and who perform robotic hysterectomy at other institutions regularly), the low number of cases may not demonstrate the full effect of the group. We realize that certain patient characteristics lend to method selection and surgeon bias that cannot be completely controlled for in our study despite efforts at isolating these characteristics with multivariate analyses. It may well be that surgeons will continue to choose a method based on concomitant procedures rather than costs, even in the absence of contraindications to recommended methods. Our decision to include hysterectomies that were performed for heterogeneous indications presents an inherent trade-off with regard to comparing the modes of access.

Despite the fact that only 8% of US physicians would choose abdominal hysterectomy as the preferred ap-

proach for themselves or their spouse,[14] barriers still remain preventing minimally invasive surgery. Vaginal hysterectomy is thought to be performed in only 19% of eligible patients, with proposed barriers including lack of uterine prolapse, fibroids, or needing to perform a concurrent bilateral salpingo-oophorectomy.[15] Even in our institution, vaginal hysterectomy was geared toward nonobese patients with smaller uteri and prolapse. Similarly, since the laparoscopic technique emerged in the late 20th century,[15] it has not been adopted in a rapid fashion due to lack of training during residency, technical difficulty, and operating times.[14] Minimally invasive procedures have been previously associated with a perceived greater cost[16]; however, the perceived greater cost is not actualized in our study. These barriers to minimally invasive hysterectomy prevent cost savings from being maximized with regards to hysterectomy nationwide.

CONCLUSION

Our data show the differences in complication rates and costs among abdominal, vaginal, laparoscopic, and robotic hysterectomies. With changing technology and further cost-minimization strategies, a shift must occur toward cost-effective minimally invasive methods of hysterectomy, so the health care system can experience more savings and greater clinical excellence with regards to the most common gynecologic procedure performed.

References:

1. Agency for Healthcare Research and Quality. Health Services Research on Hysterectomy and Alternatives. http://www.ahrq.gov/research/hysterec.htm. Accessed 8/14/2010.

2. Vessey MP, Villard-Mackintosh L, McPherson K, Coulter A, Yeates D. The epidemiology of hysterectomy: findings in a large cohort study. *Br J Obstet Gynaecol.* 1992;99(5):402–407.

3. Wilcox LS, Koonin LM, Pokras R, Strauss LT, Xia Z, Peterson HB. Hysterectomy in the United States, 1988–1990. *Obstet Gynecol.* 1994;83(4):549–555.

4. Merrill RM. Prevalence corrected hysterectomy rates and probabilities in Utah. *Ann Epidemiol.* 2001;11(2):127–135.

5. Wu JM, Wechter ME, Geller EJ, Nguyen TV, Visco AG. Hysterectomy rates in the United States, 2003. *Obstet Gynecol.* 2007;110:1091–1095.

6. Choosing the Route of Hysterectomy for Benign Disease. ACOG Committee Opinion 444. *Obstet Gynecol.* 2009;114(5):1156–1158.

7. AAGL position statement: route of hysterectomy to treat benign uterine disease. *J Minim Invasive Gynecol.* 2011;18(1):1–3.

8. Mirahashemi R, Harlow BL, Ginsburg ES, Signorello LB, Berkowitz RS, Feldman S. Predicting risk of complications with gynecologic laparoscopic surgery. *Obstet Gynecol.* 1998;92:327–331.

9. Rogo-Gupta LJ, Lewin SN, Kim JH, et al. The effect of surgeon volume on outcomes and resource use for vaginal hysterectomy. *Obstet Gynecol.* 2010;116(6):1341–1347.

10. Shah NT, Wright KN, Jonsdottir GM, Jorgensen S, Einarsson JI, Muto MG. The feasibility of societal cost equivalence between robotic hysterectomy and alternate hysterectomy methods for endometrial cancer. *Obstet Gynecol Int.* 2011;2011:570464.

11. Behera MA, Likes CE 3rd, Judd JP, Barnett JC, Havrilesky LJ, Wu JM. Cost analysis of abdominal, laparoscopic, and robotic-assisted myomectomies. *J Minim Invasive Gynecol.* 2012;19(1):52–57.

12. Judd JP, Siddiqui NY, Barnett JC, Visco AG, Havrilesky LJ, Wu JM. Cost-minimization analysis of robotic-assisted, laparoscopic, and abdominal sacrocolpopexy. *J Minim Invasive Gynecol.* 2010;17(4):493–499.

13. Barnett JC, Judd JP, Wu JM, Scales CD Jr., Myers ER, Havrilesky LJ. Cost comparison among robotic, laparoscopic, and open hysterectomy for endometrial cancer. *Obstet Gynecol.* 2010;116(3):685–693.

14. Einarsson JI, Matteson KA, Schulkin J, Chavan NR, Sangi-Haghpeykar H. Minimally invasive hysterectomies - a survey on attitudes and barriers among practicing gynecologists. *J Minim Invasive Gynecol.* 2010;17(2):167–175.

15. Davies A, Vizza E, Bournas N, O'Connor H, Magos A. How to increase the proportion of hysterectomies performed vaginally. *Am J Obstet Gynecol.* 1998;179(4):1008–1012.

16. Bijen CB, Vermeulen KM, Mourits MJ, de Bock GH. Costs and effects of abdominal versus laparoscopic hysterectomy: systematic review of controlled trials. *PLoS One.* 2009;4(10):e7340.