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 χ² 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 40² 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.
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 manipulation, 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. 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 χ² 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 gynecologic 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.
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 1.
Patient Demographics (n=581)

|              | Abdominal | Vaginal | Laparoscopic | Robotic |
|--------------|-----------|---------|--------------|---------|
| Total        | 185 (26.89) | 135 (19.62) | 354 (51.45) | 14 (2.03) |
| Age (years)  | 48.42 (9.15) | 55.83 (12.55) | 46.86 (7.82) | 47.93 (10.41) |
| BMI (kg/m²)  | 30.03 (8.13) | 26.93 (4.22) | 28.75 (6.84) | 35.56 (13.4) |
| Uterine weight (grams) | 598.94 (693.45) | 99.63 (68.33) | 248.84 (222.35) | 144.79 (89.44) |
| Prior laparotomy | 67 (41.61) | 29 (27.62) | 137 (45.07) | 6 (54.55) |
| Prior laparoscopy | 34 (21.66) | 28 (25.45) | 94 (31.23) | 6 (50.00) |
| Adhesions     | 62 (33.51) | 3 (2.24) | 83 (23.65) | 11 (78.57) |

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

|                | Abdominal | Vaginal | Laparoscopic | Robotic |
|----------------|-----------|---------|--------------|---------|
| Operative Time (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 (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 (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    | —         | 1 (.74) | 10 (2.82) | 0 |
| Organ Injury   | 2 (1.10) | 1 (.75) | 1 (.29) | 0 |
| EBL >=1000 (mL) | 3 (1.66) | 1 (.75) | 1 (.30) | 0 |

*Mean, standard deviation (95% Confidence interval), (Student t test, with ‘Abdominal’ as reference group).

*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 oc-
hurred in 5 abdominal cases, 2 vaginal cases, 2 laparo-
coscopic cases, and no robotic cases. Costs and mean dif-
fferences in costs between each method are reported
and examined for significance in Table 3. All patient OR costs
were significantly different, with vaginal hysterectomy be-
ing the least expensive at $26,690 and robotic hystere-
tomy being the most expensive at $43,794. The difference
in cost between abdominal and robotic hysterectomy be-
came insignificant when we accounted for inpatient stay.
Mean total patient costs were $43,622 for abdominal,
$31,934 for vaginal, $38,312 for laparoscopic, and $49,526
for robotic hysterectomies. Multivariate regression analy-
ses 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 hys-
terectomy 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 hysterec-
tomy, 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 hystere-
tomy. 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 patients10; however, it reflects
gynecology literature that finds the robotic method to be the
most expensive method for other benign gynecologic pro-
cedures including myomectomy11 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 |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Patient OR Cost ($) | A bd | V ag | L sc | R ob | A-V | A-L | A-R | V-L | V-R | L-R |
|---------------------|------|------|------|------|------|------|------|------|------|------|
| A bd | 31084 | 26900 | 33879 | 43794 | 4394.40 | -2795 | -12709 | -7109 | -17104 | -9914 |
| V ag | 7702.90 | 9205 | 9791.30 | 10609 | 8368.80 | 9129.70 | 7927.60 | 9633.60 | 9337.60 | 9821.50 |
| L sc | (2530.70, 6258.20) | (-4422, -1168) | (-17043, -8376) | (-5275, -11922) | (-4422, -1168) | (-17043, -8376) | (-5275, -11922) | (-4422, -1168) | (-17043, -8376) | (-5275, -11922) |
| R ob | 11688 | 5310.70 | -5904 | -6377 | -17592 | -11215 |
| A-V | (2460.70, 15225) | (8154.60, 3501.60) | (3482, -10369) | (3220, -19209) |
| A-L | p<.0001 | p=.003 | p<.0001 | p<.0001 | p=.0002 |
| A-R | p=.0061 |
| V-L | p=.0001 |
| V-R | p<.0001 |
| L-R | p<.0001 |
| Total Patient Cost ($) | 43622 | 31934 | 38312 | 49526 | 11688 | 5310.70 | -5904 | -6377 | -17592 | -11215 |
| A-V | (2460.70, 15225) | (8154.60, 3501.60) | (3482, -10369) | (3220, -19209) |
| A-L | p<.0001 | p=.0061 |
| A-R | p<.0001 |
| V-L | p<.0001 |
| V-R | p<.0001 |
| L-R | p<.0001 |

*Mean, standard deviation (Student t test, with reference group as specified).*
numbers in the literature. 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.

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 | -0.079 | .743 | .2884 |
| Prior Laparotomy    | 3.349 | 5.457 | .5398 | -291.486 | 292.306 | .3194 | 920.627 | 705.804 | .1930 |
| Prior Laparoscopy   | -1.53 | 5.935 | .9795 | -107.757 | 317.692 | .7347 | -832.593 | 767.100 | .2785 |
| Adhesions           | 21.916 | 6.373 | .0007 | 768.790 | 346.830 | .0273 | -895.937 | 837.699 | .2856 |

Despite the fact that only 8% of US physicians would choose abdominal hysterectomy as the preferred ap-
proach for themselves or their spouse, 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. 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, it has not been adopted in a rapid fashion due to lack of training during residency, technical difficulty, and operating times. Minimally invasive procedures have been previously associated with a perceived greater cost; 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.

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