Use and Benefits of Laparoscopic Hysterectomy for Stage I Endometrial Cancer Among Medicare Beneficiaries

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Abstract

Purpose: Laparoscopic hysterectomy is associated with shorter hospital stays, less postoperative pain, and earlier resumption of activity. We analyzed predictors of access to laparoscopy and compared the outcomes of laparoscopic and open hysterectomy for stage I endometrial cancer.

Methods: Using the SEER-Medicare database we examined women 65 years of age with stage I endometrial cancer who underwent hysterectomy between 1997 and 2005. The associations of patient, tumor, and physician-related factors with use of laparoscopic hysterectomy were analyzed. Surgical quality, morbidity, and survival were compared.

Results: We identified 8,545 patients, including 8,018 (93.8%) who underwent abdominal hysterectomy and 527 (6.2%) who had a laparoscopic hysterectomy. Performance of laparoscopic

hysterectomy increased from 3.9% in 1997 to 8.5% in 2005. More recent year of diagnosis, younger age, white race, fewer comorbidities, higher socioeconomic status, lower tumor grade and stage, and residence in a metropolitan area were associated with use of laparoscopy ($P < .05$ for each). Physician characteristics associated with performance of laparoscopy included training in the United States, specialization in gynecologic oncology, academic practice, and later year of graduation ($P < .05$ for all). Surgical site complications (odds ratio [OR] = 0.46; 95% CI, 0.30 to 0.71) and medical complications (OR = 0.67; 95% CI, 0.47 to 0.95) were less common in patients who underwent laparoscopy. The route of hysterectomy had no effect on cancer-specific survival (OR = 0.74; 95% CI, 0.38 to 1.44).

Conclusion: Despite the fact that laparoscopic hysterectomy for endometrial cancer results in fewer complications, uptake has been slow.

Introduction

The majority of women diagnosed with endometrial cancer are treated surgically and undergo hysterectomy. Hysterectomy, often in combination with oophorectomy and lymphadenectomy, is traditionally performed via a midline laparotomy. Although the procedure results in excellent oncologic outcomes, hysterectomy is also associated with substantial morbidity. In one prospective evaluation, abdominal hysterectomy was associated with a major complications, including intraoperative organ injury, infection, hemorrhage, or wound dehiscence in 17% of women, and an additional 20% of patients experienced minor complications.¹

Efforts to reduce the perioperative morbidity of hysterectomy have resulted in a number of surgical innovations. Laparoscopic hysterectomy for endometrial cancer was first described in 1992.² Reports describing laparoscopic hysterectomy in combination with staging lymphadenectomy followed in 1993.³ Laparoscopic hysterectomy is performed through a number of small incisions as opposed to the large central incision required for laparotomy. A number of studies^{1,4-7} have now demonstrated that laparoscopic hysterectomy for endometrial cancer is feasible and safe. Compared with laparotomy, laparoscopic hysterectomy has been associated with shorter hospital stays, less postoperative pain, and earlier resumption of daily activities.^{1,5,6,7-9}

Despite the potential benefits of laparoscopic hysterectomy for endometrial cancer, a number of questions remain unanswered. First, data suggest that adoption of laparoscopy has

been slow because some patients do not have access to the technology.¹⁰⁻¹³ Second, the majority of outcomes data reported have come from highly experienced surgeons and centers.^{4,7} Although informative, the same results may not be generalizable when the procedure is performed by less experienced surgeons. The role of comparative effectiveness research in evaluating surgical techniques and technologies such as laparoscopic hysterectomy is discussed in a recent article¹⁴ and editorial¹⁵ in *Journal of Clinical Oncology*.

The goal of our analysis was to examine the diffusion of laparoscopic hysterectomy for endometrial cancer. We examined the uptake of laparoscopic hysterectomy in a population-based analysis of elderly women with endometrial cancer and compared the outcomes of laparoscopic and open hysterectomy in women treated throughout the United States.

Methods

Data Source

We analyzed data from the linked Surveillance, Epidemiology, and End Results (SEER) -Medicare database.¹⁶ SEER is a population-based database that provides information on tumor histology, location, stage of disease, treatment, and survival, as well as demographic and selected census tract-level information. The Medicare database includes Medicare part A (inpatient) and part B (outpatient) eligibility status, billed claims, and di-

agnoses. These two files are linked and provide the ability to determine the type of surgical procedure and the dates of service. Exemption from the Columbia University institutional review board was obtained.

Patient Selection

We analyzed women with tumors of the uterine corpus who were diagnosed between January 1, 1997 and December 31, 2005 and underwent surgical treatment. Only patients with endometrioid adenocarcinomas (8380/3, 8381/3, 8382/3, 8383/3) and adenocarcinoma not otherwise specified (8140/3) were included. Patients with stage I (A, B, and C) tumors were included. We excluded patients who were enrolled in a non-Medicare health maintenance organization because the billing claims for these patients are not submitted to Medicare for reimbursement.¹⁷ Patients who were enrolled in Medicare because of end-stage renal disease and dialysis rather than age as well as patients with other primary cancers were also excluded.

Surgical Procedures

The cohort was stratified on the basis of the primary surgical procedure performed. Procedures were defined by International Classification of Disease, Ninth Revision (ICD-9) and Common Procedural Terminology (CPT) codes. Women who underwent a laparoscopic or laparoscopically assisted vaginal hysterectomy were included in the laparoscopic hysterectomy group. Patients who had claims for a diagnostic laparoscopy in combination with a vaginal hysterectomy were also included in the laparoscopic hysterectomy cohort. Patients who underwent laparotomy in combination with hysterectomy were included in the abdominal hysterectomy group. Performance of lymphadenectomy was determined on the basis of SEER data for the number of nodes removed. The number of nodes removed was classified as: 0, 1-5, 6-10, 11-15, 16-20 and 20.

Patient Characteristics

Age at diagnosis was categorized into 5-year intervals. We recoded the SEER marital status variable as married, not married, and unknown. We generated an aggregate socioeconomic status (SES) score from education, poverty level, and income data from the 2000 census tract data, as described previously by Du et al.¹⁸ Patients' scores were ranked on a scale of 1 to 5 by use of the formula that incorporated education, poverty, and income weighted equally, with 1 being the lowest value. To assess the prevalence of comorbid disease in our cohort, we used the Klabunde adaptation of the Charlson comorbidity index (ie, the Klabunde-Charlson index).^{19,20} Medicare inpatient and outpatient claims were searched for diagnostic codes of the ICD-9, Clinical Modification. Each condition was weighted, and patients were assigned a score that was based on the Klabunde-Charlson index.²⁰ Area of residence was categorized as metropolitan or nonmetropolitan, and tumor grade was grouped as well, moderately, or poorly differentiated or unknown. Receipt of radiation was characterized using Medicare billing data as none, brachytherapy, external beam radiation (including with brachytherapy), and other.

Physician Characteristics

We matched the primary surgeon to the procedure by use of the physician's Unique Physician Identification Number (UPIN) on the hysterectomy claim that was linked to the American Medical Association master file. The primary surgeon was chosen on the basis of a previously described algorithm.^{21,22} When multiple surgeons were involved in the care of a patient, we attributed the procedure to the most specialized surgeon. If a gynecologic oncologist was involved in the surgery we chose the gynecologic oncologist as the primary surgeon. If no gynecologic oncologist was involved, we classified the primary physician as a general gynecologist if involved; if neither a gynecologic oncologist nor a general gynecologist was involved, a general surgeon was chosen as the primary surgeon if involved. Patients who had procedures not associated with the UPIN of physicians with any of these three specialties were coded as unknown. Physicians' characteristics that were analyzed included sex, year of graduation, primary employment setting (private *v* government/academic), location of training (United States *v* other), and type of degree (Doctor of Medicine [MD] versus Doctor of Osteopathic Medicine [DO]).

Outcomes

Morbidity and mortality were the primary outcome variables. Perioperative morbidity, based on ICD-9 and CPT coding, was classified into the following categories: (1) intraoperative complications (bladder injury, ureteral injury, intestinal injury, vascular injury, other operative injury), (2) surgical site complications (wound complications, abscess, hemorrhage, bowel obstruction, ileus), (3) medical complications (venous thromboembolism, myocardial infarction, cardiopulmonary arrest, respiratory failure, renal failure, stroke, bacteremia/sepsis, shock, pneumonia). We also analyzed rates of transfusion and hospital readmission. Perioperative mortality was defined as death within 30 days of the primary procedure. Cancer-specific and overall survival were evaluated for each surgical group.

Statistical Analyses

Variables associated with the performance of each type of hysterectomy were compared by using χ^2 tests. We used generalized estimating equations methodology to account for the correlations of outcome measures among patients who had the same physician. The unit of analysis was the patient. For each patient, the physician's unique UPIN number was used as the clustering variable. Generalized estimating equations models were developed to analyze factors associated with performance of laparoscopy and to examine the effect of the type of hysterectomy on morbidity. Survival was examined by using Kaplan-Meier analysis and compared with log-rank tests. Cox proportional hazards models were used to examine the influence of the type of hysterectomy on survival while controlling for other clinical and demographic covariates. All analyses were conducted with SAS, version 9.13 (SAS Institute, Cary, NC). All statistical tests were two-sided.

Results

A total of 8,545 patients, including 8,018 (93.8%) who underwent an abdominal hysterectomy and 527 (6.2%) who had a laparoscopic hysterectomy, were identified. Performance of laparoscopic hysterectomy increased with time from 3.9% in 1997 to 8.5% in 2005 (Appendix Table A1, online only, Figure 1). Patients who were younger, white, married, had fewer comorbidities, and resided in metropolitan areas were more likely to undergo laparoscopy ($P < .05$ for each). Among women in the highest SES strata, 9.0% had a laparoscopic hysterectomy compared with 5.4% of patients in the lowest SES class ($P < .0001$). Laparoscopy was performed in 8.1% of patients with stage IA tumors compared with 5.5% of those with stage IC neoplasms ($P < .001$). Physician characteristics associated with performance of a laparoscopic procedure included training in the United States, specialization in gynecologic oncology, and later year of graduation ($P < .05$ for all). Physicians in academic practice performed laparoscopic hysterectomy more frequently than private practitioners ($P = .006$).

In our multivariable model, year of diagnosis was the strongest predictor of performance of laparoscopy; the odds ratio (OR) for patients who underwent surgery from 2002 to 2005 was 2.65 (95% CI, 2.10 to 3.35; Table 1) compared with women treated earlier. Patients with moderately and poorly differentiated tumors were less likely to undergo laparoscopy. Surgeons who graduated medical school more recently were more likely to perform laparoscopy; the OR for physicians who graduated from medical school in the 1960s was 0.39 (95% CI, 0.25 to 0.61). There was a borderline association between having an MD degree (OR = 1.78; 95% CI, 0.97 to 3.25) and training in the United States (OR = 1.40; 95% CI, 0.99 to 1.97) and use of laparoscopy.

Women who underwent laparoscopic hysterectomy were less likely to undergo lymphadenectomy than those who had an abdominal procedure (54.3% v 50.0%; $P < .001$; Table 2). However, among women who underwent lymphadenectomy, more nodes were removed in patients who had a laparoscopy (24.3% v 19.4% of patients with > 15 nodes removed; $P < .001$). Adjuvant radiotherapy (either brachytherapy or external beam radiation) was administered to 21.0% of patients who underwent abdominal hysterectomy compared with 14.1% of those who had a laparoscopic procedure ($P = .002$).

We then examined perioperative morbidity (Table 2). Major perioperative complications occurred in 1,864 (23.3%) women who underwent abdominal hysterectomy compared with 85 (16.1%) who had laparoscopic surgery ($P < .001$). After adjustment for other patient and physician characteristics, the overall complication rate remained lower in women who underwent laparoscopic hysterectomy (OR = 0.62; 95% CI, 0.47 to 0.82). Intraoperative complications were similar for women who had laparoscopy compared with those who had an open hysterectomy (3.8% v 2.8%, $P = .13$; multivariable OR = 0.89; 95% CI, 0.48 to 1.67). In contrast, surgical site complications (6.3% v 11.9%, $P < .001$; multivariable OR = 0.46; 95% CI, 0.30 to 0.71) and medical complications (8.9% v 13.3%, $P = .004$; multivariable OR = 0.67; 95% CI, 0.47 to

Figure 1. Uptake of laparoscopic hysterectomy for endometrial cancer, 1997 to 2005.

0.95) were less frequent for patients in the laparoscopy cohort. Transfusion rates (2.3% v 2.5%, $P = .73$) were similar.

The route of hysterectomy had no effect on cancer-specific survival (OR = 0.74; 95% CI, 0.38 to 1.44; Appendix Table A2, online only). Advanced age, higher tumor stage and grade, and nodal metastasis were associated with decreased survival. In a Kaplan-Meier analysis, route of hysterectomy had no effect on cancer-specific survival for either stage IA ($P = .18$) or stage IB/IC/I not otherwise specified ($P = .12$; Appendix Figure A1, online only).

Discussion

The uptake of laparoscopic hysterectomy for endometrial cancer has been decidedly slow. Over the course of our study, the use of laparoscopy increased from 4% in 1997 to only 8% by 2005. To place these findings into context, Miller et al²³ reported that more than 70% of cholecystectomies were performed laparoscopically 5 years after the procedure was described, whereas 60% of funduplications were laparoscopic 10 years after development of the operation. The same authors noted that uptake of laparoscopic nephrectomy was slower. When specifically analyzing nephrectomy for cancer, fewer than 10% of cases were performed laparoscopically a decade after introduction of the procedure.²⁴ A multitude of factors likely underlie the slow uptake of laparoscopic hysterectomy. Compared to an open procedure, laparoscopic surgery takes significantly longer and is often reimbursed at the same rate.^{5,7} In addition, laparoscopic hysterectomy is technically demanding and entails a steep learning curve.^{25,26} One analysis suggested that when laparoscopic hysterectomy was performed for nonmalignant disease, 30 procedures were required for the provider to achieve proficiency.²⁵

The development of an innovative surgical technology is a dynamic process. One model proposed a staged developmental paradigm for new technologies. The earliest stages (0-1) occur when highly selected surgeons describe a new technology. This is followed by a phase in which a few innovators develop the technology (stage 2a), which is then explored by a wider group of early adaptors (stage 2b). A stage of assessment (stage 3)

Table 1. Logistic Regression Model of Factors Predictive of Use of Laparoscopy

Factor	Laparoscopic Hysterectomy	
	Odds Ratio	95% CI
Age at diagnosis, years		
65-69		Referent
70-74	0.92	0.70 to 1.21
75-79	0.88	0.65 to 1.18
≥ 80	0.95	0.70 to 1.28
Race/ethnicity		
White		Referent
Black	0.91	0.50 to 1.65
Hispanic	0.89	0.32 to 2.50
Missing or other	1.53	0.97 to 2.43
Year of diagnosis		
1997-2001		Referent
2002-2005	2.65	2.10 to 3.35*
Residence		
Metropolitan		Referent
Nonmetropolitan	1.04	0.69 to 1.55
Marital status		
Married		Referent
Unmarried	0.78	0.63 to 0.98*
Unknown	1.27	0.75 to 2.15
Socioeconomic status		
Lowest (first) quintile		Referent
Second quintile	0.64	0.41 to 0.99
Third quintile	0.63	0.41 to 0.97*
Fourth quintile	0.81	0.53 to 1.25
Highest (fifth) quintile	1.20	0.79 to 1.82
Comorbidity score		
0		Referent
1	0.96	0.76 to 1.23
> 1	0.67	0.48 to 0.94*
Tumor stage		
IA		Referent
IB	0.70	0.54 to 0.90*
IC	0.81	0.59 to 1.10
I NOS	0.86	0.55 to 1.34
Tumor grade		
Well differentiated		Referent
Moderately differentiated	0.67	0.53 to 0.84*
Poorly differentiated	0.42	0.28 to 0.61*
Unknown	0.26	0.13 to 0.49*
Surgeon training		
Non-US		Referent
United States	1.40	0.99 to 1.97
Surgeon degree		
DO		Referent
MD	1.78	0.97 to 3.25

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Table 1. (Continued)

Factor	Laparoscopic Hysterectomy	
	Odds Ratio	95% CI
Surgeon specialty		
Gynecologic oncologist		Referent
Obstetrician/gynecologist	1.00	0.80 to 1.26
General surgeon	0.64	0.30 to 1.35
Unknown		
Surgeon sex		Referent
Male	0.99	0.76 to 1.29
Female		
Surgeon decade of graduation		
1990s		Referent
1980s	0.99	0.71 to 1.37
1970s	0.75	0.52 to 1.07
1960s	0.39	0.25 to 0.61*
Oncologist practice setting		
Academic		Referent
Private practice	0.83	0.66 to 1.05

Abbreviations: DO, doctor of osteopathic medicine; NOS, not otherwise specified.
* $P < .05$.

follows, in which many surgeons (early majority) embrace and begin using a technology. If successful, the final stage (stage 4) of the model describes a period when the vast majority of surgeons are using a technology and long-term outcomes data are described.²⁷ Many new procedures and devices diffuse into practice with only minimal data, and how best to evaluate new technologies and manage their implementation into practice is an ongoing debate.²⁸

For many laparoscopic procedures, patient characteristics have been shown to affect access to care; black patients, the elderly, women, the uninsured, and patients with low SES are less likely to undergo a minimally invasive procedure.^{10-12,24,29,30} For hysterectomy, white women are more than twice as likely as black women to undergo laparoscopy, and privately insured patients were 50% more like to undergo a minimally invasive appendectomy than patients with Medicaid.^{10,29} In our analysis, year of diagnosis was the most important predictor of access to laparoscopy, but sociodemographic factors also exerted an influence on access to laparoscopy.

Surgical practice patterns are influenced not only by patient characteristics, but also by a multitude of physician factors.^{13,31,32} In an analysis of patients who underwent sigmoid colectomy for diverticular disease, patients treated by high-volume surgeons were more than eight times more likely to undergo a laparoscopic procedure.¹³ Likewise, physician training and specialization appear to exert substantial influences on the use of minimally invasive techniques. Because laparoscopy was not in widespread use until the 1990s, surgeons who completed training before that time are likely to incorporate laparoscopy into their practice more slowly.^{33,34} In our analysis, physician training and specialization influenced uptake of laparoscopy, and year of medical school graduation, a surrogate for physician

Table 2. Use of Lymphadenectomy, Adjuvant Radiation, and Perioperative Morbidity for Women Who Underwent Abdominal and Laparoscopic Hysterectomy

Variable	Abdominal Hysterectomy		Laparoscopic Hysterectomy		P	Multivariable OR Laparoscopic Hysterectomy	95% CI
	No.	(%)	No.	(%)			
Any complication	1,864	23.3	85	16.1	< .001	0.62	0.47 to 0.82*
Intraoperative complications	222	2.8	20	3.8	.17	0.89	0.48 to 1.67
Bladder injury	40	0.5	8	1.5			
Ureteral injury	82	1.0	8	1.5			
Intestinal injury	78	1.0	3	0.6			
Vascular injury	8	0.1	0	—			
Other operative injury	42	0.5	2	0.4			
Surgical site complications	951	11.9	33	6.3	< .001	0.46	0.30 to 0.71*
Wound complication	271	3.3	4	0.8			
Abscess	256	3.2	9	1.7			
Hemorrhage	129	1.6	5	1.0			
Bowel obstruction	202	2.5	10	1.9			
Ileus	302	3.8	10	1.9			
Medical complications	1,065	13.3	47	8.9	.004	0.67	0.47 to 0.95*
Venous thromboembolism	271	3.4	9	1.7			
Myocardial infarction	57	0.7	3	0.6			
Cardiopulmonary arrest	27	0.3	0	—			
Respiratory failure	565	7.1	20	3.8			
Renal failure	95	1.2	4	0.8			
Stroke	71	0.9	3	0.6			
Bacteremia/sepsis	76	1.0	7	1.3			
Shock	101	1.3	4	0.8			
Pneumonia	223	2.8	9	1.7			
Utilization							
Transfusion	202	2.5	12	2.3	.73	0.95	0.48 to 1.91
Lymph nodes removed					< .001		
None	4,007	50.0	286	54.3			
1-5	998	12.5	31	5.9			
6-10	805	10.0	43	8.2			
11-15	651	8.1	39	7.4			
16-20	476	5.9	35	6.6			
> 20	1,081	13.5	93	17.7			
Adjuvant radiation					.001		
None	6,149	77.2	446	84.8			
Brachytherapy	427	5.4	22	4.2			
External beam radiation†	1,240	15.6	52	9.9			

Abbreviation: OR, odds ratio.

* $P < .05$.

† Includes external beam radiation alone or in combination with brachytherapy.

age, had a particularly strong impact on performance of laparoscopy. The fact that a lower percentage of women in the laparoscopy group underwent lymphadenectomy suggests that inability to perform a laparoscopic lymphadenectomy may have in part dissuaded physicians from laparoscopy.

Although our study benefits from the inclusion of a large number of patients, we acknowledge a number of important

limitations. Complications are underreported in administrative data. To minimize this effect, we analyzed only major perioperative complications that were likely to generate a claim. Although this minimizes underreporting bias, it limits our ability to capture more subtle and minor morbidities that are inconsistently coded. Further, the number of laparoscopic procedures performed during the study period reduced our power to detect

differences in specific complications between the two procedures. We cannot exclude the possibility that the type of primary surgery performed differed from what was coded in the SEER-Medicare data set. A priori we limited our analysis to only those years in which there was a well recognized code for laparoscopically assisted hysterectomy. In addition, we comprehensively analyzed both hospital and physician billing records to ensure the accuracy of our coding schema. SEER lacks data on a number of technical factors that affect the surgical approach chosen, such as uterine size. To make the groups as comparable as possible, we included only patients with uterine-confined disease and analyzed only patients with endometrioid histology. Sensitivity analyses were performed in which patients with stage IIIC disease were included, and our findings were unchanged. Despite the fact that we used an accepted methodology to measure comorbidity, complete risk adjustment is not possible using registry data and may have influenced our findings. In addition to tumor factors, there are likely a number of physician and patient factors that influenced treatment selection that are impossible to measure using administrative data. Finally, although we examined survival, we did not analyze recurrence, as it is difficult to determine patterns of recurrence using SEER data.

We were reassured to note that laparoscopic hysterectomy appeared to be a safe alternative with fewer complications than open surgery. Several reports, most from highly experienced surgeons and centers, have suggested that laparoscopic hysterectomy is a viable option for endometrial cancer.^{1,4,5,7-9} A randomized trial of 2,600 women conducted by the Gynecologic Oncology Group noted that the length of stay was shorter for women randomly assigned to laparoscopy, although the median surgery time was longer. The rate of surgical complications was similar for the two groups, although postoperative adverse events were less frequent in women assigned to laparoscopy.⁷ Over the 6-week postoperative period, laparoscopy was associated with better physical functioning, improved body image, earlier resumption of work, and improved quality of life. Early postoperative differences in quality of life were noted between laparoscopy and laparotomy, but the two groups were nearly equal 6 months after surgery.⁶ Survival results for this trial have not yet been reported.⁷ In our analysis, the overall complication rate was lower in women who underwent laparoscopy, and the route of hysterectomy had no effect on survival. Somewhat surprisingly, women who underwent laparoscopy were less likely to undergo lymphadenectomy.

The major question raised by our report is how to increase the diffusion of minimally invasive surgery for women with endometrial cancer. A 2008 survey of gynecologic oncologists noted that only 8% of respondents used laparoscopy in more than 50% of their cases.³⁵ While uptake of minimally invasive surgery is clearly complex, a survey of physicians that examined

the diffusion of laparoscopy suggested that regional practice in a competitive market and fee-for-service payment were among the strongest driving forces to adopt laparoscopic surgery early.³⁶ The favorable results of the Gynecologic Oncology Group trial will likely further stimulate the use of laparoscopic hysterectomy for endometrial cancer. In addition, the past 5 years have seen the introduction of robotic hysterectomy, which may also promote minimally invasive hysterectomy. Given the growing body of evidence showing the benefits of laparoscopic surgery for endometrial cancer, prospective initiatives to ensure access to high-quality, minimally invasive surgery for women are clearly needed.

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Appendix

Table A1. Univariate Analysis of Factors Associated With Laparoscopic Hysterectomy

Factor	Abdominal Hysterectomy		Laparoscopic Hysterectomy		P	Unadjusted Odds Ratio	95% CI
	No.	(%)	No.	(%)			
No. of patients	8,018	93.8	527	6.2			
Age at diagnosis, years					.02		
65-69	2,432	92.7	193	7.4		Referent	
70-74	2,119	94.1	134	6.0		0.80	0.63 to 1.00
75-79	1,779	94.4	106	5.6		0.75	0.59 to 0.96*
≥ 80	1,688	94.7	94	5.3		0.70	0.54 to 0.91*
Race/ethnicity					.002		
White	7,266	93.9	471	6.1		Referent	
Black	345	95.8	15	4.2		0.67	0.40 to 1.13
Hispanic	105	95.5	5	4.6		0.74	0.30 to 1.81
Missing or other	302	89.4	36	10.7		1.84	1.29 to 2.63*
Year of diagnosis					< .001		
1997	788	96.1	32	3.9		Referent	
1998	645	95.0	34	5.0		1.30	0.79 to 2.13
1999	586	96.1	24	3.9		1.01	0.59 to 1.73
2000	1,127	95.4	54	4.6		1.18	0.76 to 1.84
2001	1,055	94.2	65	5.8		1.52	0.98 to 2.34
2002	1,054	93.4	75	6.6		1.75	1.15 to 2.68*
2003	955	91.8	85	8.2		2.19	1.44 to 3.33*
2004	875	92.5	71	7.5		2.00	1.30 to 3.07*
2005	933	91.5	87	8.5		2.30	1.52 to 3.48*
Residence					.03		
Metropolitan	7,211	93.7	489	6.4		Referent	
Nonmetropolitan	807	95.5	38	4.5		0.69	0.50 to 0.97*
Marital status					< .001		
Married	3,787	92.8	295	7.2		Referent	
Unmarried	3,958	94.9	211	5.1		0.68	0.57 to 0.82*
Unknown	273	92.9	21	7.1		0.99	0.62 to 1.56
Socioeconomic status					< .001		
Lowest (first) quintile	662	94.6	38	5.4		Referent	
Second quintile	1,617	95.2	81	4.8		0.87	0.59 to 1.30
Third quintile	1,981	95.2	101	4.9		0.89	0.61 to 1.30
Fourth quintile	1,805	94.0	115	6.0		1.11	0.76 to 1.62
Highest (fifth) quintile	1,953	91.1	192	9.0		1.71	1.20 to 2.45*
Comorbidity score					.002		
0	4,601	93.2	334	6.8		Referent	
1	2,124	93.9	137	6.1		0.89	0.72 to 1.09
> 1	1,293	95.9	56	4.2		0.60	0.45 to 0.80*
Tumor stage					< .001		
IA	1,739	91.9	154	8.1		Referent	
IB	3,905	94.3	237	5.7		0.69	0.56 to 0.85*
IC	1,775	94.5	104	5.5		0.66	0.51 to 0.86*
I NOS	599	94.9	32	5.1		0.60	0.41 to 0.89*

Continued on next page

Table A1. (Continued)

Factor	Abdominal Hysterectomy		Laparoscopic Hysterectomy		P	Unadjusted odds ratio	95% CI
	No.	(%)	No.	(%)			
Tumor grade					< .001		
Well differentiated	3,399	91.9	300	8.1		Referent	
Moderately differentiated	2,919	94.4	173	5.6		0.67	0.55 to 0.82*
Poorly differentiated	1,222	96.7	42	3.3		0.39	0.28 to 0.54*
Unknown	478	97.6	12	2.5		0.29	0.16 to 0.51*
Surgeon training					< .001		
Non-US	1,333	96.9	43	3.1		Referent	
United States	5,799	94.3	353	5.7		1.95	1.41 to 2.69*
Surgeon degree					.13		
DO	332	96.5	12	3.5		Referent	
MD	680	94.7	384	5.4		1.60	0.89 to 2.87
Surgeon specialty					< .001		
Gynecologic oncologist	2,459	94.2	152	5.8		Referent	
Obstetrician/gynecologist	4,377	94.9	236	5.1		0.90	0.73 to 1.11
General surgeon	206	99.5	1	0.5		0.08	0.01 to 0.58*
Unknown	976	87.6	138	12.4			
Surgeon sex					.08		
Male	5,884	95.0	313	5.1		Referent	
Female	1,248	93.8	83	6.2		1.27	1.00 to 1.62
Surgeon decade of graduation					< .001		
1960s	1,710	97.6	42	2.4		Referent	
1970s	2,416	95.1	125	4.9		2.10	1.48 to 3.00*
1980s	2,310	93.1	171	6.9		3.12	2.22 to 4.39*
1990s	696	92.3	58	7.7		3.42	2.28 to 5.12*
Oncologist practice setting					.006		
Academic	1,877	93.6	129	6.4		Referent	
Private	5,255	95.2	267	4.8		0.75	0.61 to 0.93*

Abbreviations: DO, doctor of osteopathic medicine; NOS, not otherwise specified.

* $P < .05$.

Table A2. Cox Proportional Hazards Model of Cancer-Specific Mortality for Women With Endometrial Cancer

Variable	Laparoscopic Hysterectomy	
	Odds Ratio	95% CI
Hysterectomy		
Abdominal	Referent	
Laparoscopic	0.74	0.38 to 1.44
Age at diagnosis, years		
65-69	Referent	
70-74	0.94	0.66 to 1.35
75-79	1.21	0.85 to 1.71
≥ 80	2.20	1.59 to 3.03*
Race/ethnicity		
White	Referent	
Black	1.24	0.75 to 2.03
Hispanic	0.74	0.27 to 2.04
Missing or other	1.40	0.84 to 2.32
Year of diagnosis		
1997-2001	Referent	
2002-2005	0.76	0.59 to 0.99*
Residence		
Metropolitan	Referent	
Nonmetropolitan	1.12	0.77 to 1.63
Marital status		
Married	Referent	
Unmarried	1.23	0.96 to 1.58
Unknown	1.12	0.60 to 2.10
Socioeconomic status		
Lowest (first) quintile	Referent	
Second quintile	0.68	0.45 to 1.03
Third quintile	0.56	0.37 to 0.86*
Fourth quintile	0.70	0.46 to 1.07
Highest (fifth) quintile	0.51	0.33 to 0.80*
Comorbidity score		
0	Referent	
1	1.14	0.88 to 1.48
> 1	1.07	0.77 to 1.48
Tumor stage		
IA	Referent	
IB	0.92	0.64 to 1.31
IC	1.65	1.12 to 2.42*
I NOS	1.98	1.27 to 3.07*
Tumor grade		
Well differentiated	Referent	
Moderately differentiated	2.10	1.49 to 2.97*
Poorly differentiated	6.25	4.44 to 8.80*
Unknown	3.18	1.90 to 5.34*
Radiation		
No	Referent	
Brachytherapy	0.90	0.33 to 2.45
External beam	1.48	1.13 to 1.94*

Abbreviation: NOS, not otherwise specified.

* $P < .05$.

Figure A1. Cancer-specific survival stratified by type of surgery for women with (A) stage IA tumors ($P = .18$) and (B) stage IB/IC/I not otherwise specified tumors ($P = .12$).